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TUBERCULOSIS, LEPROSY AND ALLIED MYCOBACTERIAL DISEASES[1]

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IN the earliest epochs of medical history diseases were classified empirically according to simple symptoms and obvious signs as fevers, tumors, declines and the like, and it was centuries, even, before a more exacting science added an organic incrimination so that physicians could speak more expertly of lung fever, renal dropsy, splenic anemia or pancreatic diabetes. To-day the trend is to set diseases apart on the seemingly rational basis of etiology. Thus lung fever has given way to pneumonia and brain fever to meningitis, with a definite causal association in the mind of speaker and listener with respect to the latter terms. To the ancient physician a febrile disease in which the patient remained in a stuporous or "typhoid" state was typhoid fever; the physician of a more enlightened age, recognizing its intestinal localization, called it enteric fever; physicians of to-day still use this term or the older one of symptomatic reference "typhoid fever," but instinctively think of the disease in terms of its cause, the "typhoid bacillus" (*Eberthella typhi*).

And just as the science of bacteriology took apart certain previous groups, like inflammations of the lungs, and set them in separate categories, so it also grouped together certain ailments once thought distinct. Formerly processes apparently as unrelated as chronic ulceration of the lungs, general swelling of the lymphatic glands, progressive destruction of the spine and cheesy degeneration of the kidneys, were separate clinical entities, although their frequent association led to some suspicion of a common underlying

[1] Address of the vice-president and chairman of the section on the Medical Sciences, American Association for the Advancement of Science, Indianapolis, December, 1937.

basis. With the discovery of the tubercle bacillus, at once they all become forms of one disease, tuberculosis.

With the advance of bacteriology, continued refinement in laboratory technique has become necessary in order to keep pace with clinical progress. The acumen of the clinician in distinguishing pneumonias of varying severity forced his colleague in the laboratory to separate the individual kinds of pneumococci. However, during the lag period, pending the requisite bacteriological progress, certain morbid processes were once set aside for the time being semianonymously as paratyphoid fever, parasyphilis, paratuberculosis and so forth.

But the course of progress in the scientific explanation of clinical facts has not always been smooth. Indeed the purpose of the present symposium of the Section on Medical Sciences of the American Association for the Advancement of Science has been to call attention to significant difficulties into which bacteriological progress has inevitably led in the effort to give full satisfaction to clinical medicine. There is a certain group of diseases easily distinguishable on the basis of symptoms and signs, and differentiable by refined technique in the laboratory, which yet have distinct bacteriological and histopathological aspects in common. The diseases are tuberculosis as it occurs in a variety of types in different animal species, leprosy, Johne's disease, or the so-called paratuberculosis of cattle, a curious bovine skin disease with as yet no limiting designation, and a motley collection of nodular ailments in birds, rodents and various cold-blooded animals, called for convenience rat "leprosy," fish "tuberculosis," etc., with little satisfaction to the namer and to the everlasting annoyance of the special experts in "true" leprosy and tuberculosis.

The significant factors in common in this group of diseases are two: (1) causation by a type of microorganism with the distinguishing tinctorial property of "acid-fastness," and (2) a host response characterized by the elaboration and local accumulation of monocytes, or large mononuclear phagocytic cells, which vary in appearance according to location and the work in hand, but seem to be of fundamentally identical origin. As a corollary of the first factor is to be mentioned a third characteristic, the common possession of certain chemical entities in the lipid, protein and carbohydrate fractions, which appear to be responsible for the distinctive staining character and certain serological reactions in common. As noted by White in the introduction, these fundamental similarities have been impressive enough to induce the National Tuberculosis Association to sponsor a long investigation in several laboratories on the fundamental facts concerned.

Were the similarities of the diseases limited to these common factors, the usual adjuncts to ordinary bacteriological and pathological technique, such as virulence tests in animals and absorption tests with serums, might prove sufficient to distinguish the causal agents accurately. The utterly confusing fact is, however, that the disease produced by one and the same microorganism changes its type in different animal species, and artificial modifications of a given microorganism cause it to induce different disease processes in the same species of animal. Indeed, the bacterial cause isolated from one clinical type of disease can, by manipulation of the organism or substitution of animal, produce a disease resembling one of the other clinical types of disease more closely than the type from which the germ was originally isolated.

With these facts in mind it seems logical to group these diseases caused by acid-fast bacteria for simultaneous discussion. The taxonomic designation *mycobacteria* for the "acid-fast" bacteria responsible for them has been adopted by the special committee on nomenclature in the Society of American Bacteriologists, and followed in the American Type Culture Collection. If we accept this it is perhaps in order to think of the whole group of diseases for the moment under the single appellation "mycobacteriosis."

Let me say at this point that I am not proposing the view that the naturally occurring ailments concerned have an overlapping bacterial etiology, or that in some past age the causal agent of one was derived from the causal agent of another by habitat and evolution. This has indeed often been suggested. I merely propose to analyze some of the known facts, and try to indicate a common pattern in these diseases, relying on future research to fill in the many gaps in our present knowledge and show what the larger significance of this common pattern may be.

The Spontaneous Mycobacterial Diseases

Such an analysis will probably have more meaning if brief pictures of the main diseases concerned are presented, or a short description is given of certain pathological processes as they occur in nature without the deliberate interference of the laboratory.

Tuberculosis has long been known as a disease afflicting man, domestic animals and birds. As Stiles has pointed out in a preceding paper of this series, it apparently affects a wider range of animal species than any other specific disease. In man it has been the great killer of the ages, in different times and places causing from one twentieth to as much as one third of the total continuing average mortality. In man it assumes many types, as indicated in the second paragraph of this paper, but in all of them either the so-called "human type" of tubercle bacillus, or the

closely related "bovine type" bacillus, is the causal agent.[2]

Of the domestic animals, cattle and swine are most prone to tuberculosis, while sheep, goats, horses, dogs and cats are considered relatively refractory. However, spontaneous tuberculosis may occur in any of them, and can be induced artificially in all. Wild animals in captivity acquire the disease and occasionally develop it when in their natural environment. Tuberculosis is a common disease of high mortality in primates in the zoological gardens, and has been found even in the lion. The economic importance of the disease is greatest in cattle, the incidence ranging from wide-spread infection involving the majority of herds of a country, where little attempt is made to combat it, to a fraction of one per cent. of the herds, where every effort is made to wipe it out, as in the United States and Canada. The disease may be transmitted from cattle to man through the medium of cow's milk, which is heavily infected in cows with tuberculous udders. According to accepted bacteriological criteria the causal agent of the cattle disease is the "bovine type" of tubercle bacillus.

Tuberculosis in swine is a disease of unknown extent. There is no general tuberculin testing of swine, comparable to the testing of cattle. It appears, however, to be sufficiently common to be of serious economic import. Its medical significance for man, however, is not great, as the organs affected are not ordinarily food products, and the flesh, which is eaten, is rarely affected, and in any event is cooked before consumption. Moreover, sow's milk, unlike cow's milk, is not an ordinary staple of diet. No special type of bacillus characteristic of swine tuberculosis has been recognized. Until relatively recently the bovine type of tubercle bacillus was accepted as the cause of swine tuberculosis, and it appears true that a decline in the latter is paralleling the drop in bovine tuberculosis. Recently, however, it has been startling to learn that as much as 90 per cent. of hog tuberculosis in some regions is due to a bacillus highly pathogenic for birds, and possessing other characteristics identifying it as the "avian" rather than the "bovine" type of bacillus. This foreshadows the main problem that I shall raise presently, but it is a fair question at the moment to ask if an initial concentration of bacteriological effort on hogs might not have given us a "swine type" of tubercle bacillus, to which it was later recognized that birds were susceptible. It is stated, however, that there is some difference in the effect of the two types of bacteria, the "avian" type causing a more or less generalized and the "bovine" type a localized glandular disease in swine.

Tuberculosis affects a wide variety of birds, as noted in Stiles's paper. Between 2 and 3 per cent. of the flocks in this country are affected, so that the economic loss is appreciable. The commercial solution of the problem seems to be slaughter of hens before they get to be old. The disease is believed to be of no medical importance as far as transmission to man is concerned, but there is every indication that the various phenomena of avian tuberculosis are of the utmost significance for our understanding of the fundamental mechanisms of tuberculosis. The disease in birds is due to a form of tubercle bacillus highly infectious for chickens on laboratory inoculation, and classified as "avian" in type. But the organism is also one of the most labile of the bacilli, as respects laboratory modification, and some strains, spontaneously occurring or artificially separated, are intensely infective for rabbits, producing rapidly fatal, generalized disease.

Tuberculosis in cold-blooded animals is a nodular disease, occurring in epidemics of more or less severity in zoological gardens, but of relatively rare occurrence in nature. Its general characteristics have been concisely presented by Aronson in a foregoing paper. Wide generalization of lesions throughout the viscera, prevalence of acid-fast bacilli in the lesions, epithelioid tubercles and caseation are characteristic. In general the disease can be transmitted from a cold-blooded animal of one species to another species of cold-blooded animal, while warm-blooded animals are not susceptible. The simplest explanation is the preference of the organism concerned for lower temperatures than that prevailing in the warm-blooded animals. However, differences in strains of this fourth type of tubercle bacilli, "the tubercle bacillus of cold-blooded animals," have been worked out by Aronson, and Gonzalez has recently found that an organism isolated from a frog, and readily affecting other frogs, is pathogenic for mice.

It will be apparent from the foregoing that a series of animal "bridges" can be used to link up the pathological processes caused by tubercle bacilli of the various types. The "human" type infects man, but not swine or fowls. The "bovine" type infects man and swine, but not fowls. The "avian" type infects swine and fowls, but not man. Guinea-pigs are readily susceptible to human and bovine, but not to avian infection, and rabbits succumb to bovine and avian, but not to human type bacillus infection. All three types of tubercle bacillus produce tubercu osis of some degree in some strains of mice, and if Gonzalez' claim is verified, the bacilli of cold-blooded animals, to which warm-blooded animals in general are refractory, may also cause tuberculosis in the mouse.

We now come to the disease of next greatest importance as far as man is concerned, *viz.*, leprosy. As

[2] Reports of tuberculosis in man caused by the "avian type" of bacillus are not generally credited in this country.

Burgess and Doull have pointed out, this disease is at present largely confined to tropical and subtropical countries, although once far more wide-spread, and still afflicts some three million people throughout the world. From the medical point of view it is a disease of many problems. The question of transmission has so far entirely escaped solution. As the several papers devoted to leprosy in this symposium have made clear, the disease has spontaneously decreased throughout recent history, and is obviously of a low order of contagion, while constitutional susceptibility apparently plays a rôle, a sexual difference being apparent, and only a fraction of those exposed contracting the disease.

The etiology has been one of the most baffling problems ever undertaken by bacteriologists. The involved tissues teem with acid-fast bacilli, and acid-fast bacilli have been repeatedly isolated, but they seem quite incapable of producing any progressive disease like leprosy. They vary greatly among themselves, but with the exception of the unusually interesting one described in this symposium by Soule and McKinley resemble the numerous common acid-fast saprophytes. Extreme views with respect to these various bacteria isolated from leprous tissues are (1) that no one of them is the cause of leprosy, the bacteria isolated being simply saprophytic acid-fast contaminants, and (2) that all of them are the cause of leprosy, attenuated and changed, one from another, as a result of artificial culture.

The notable histopathological characteristics of leprosy in its internal manifestations, described in the paper by Black, have much in common with some kinds of animal tuberculosis, such as generalized avian tuberculosis in fowls, the "Yersin" type of tuberculosis in rabbits, rat tuberculosis and various types of tuberculosis produced in laboratory animals through exaltation of virulence of some strains of tubercle bacilli. Yet leprosy is a disease of great chronicity. Immunologically it does not seem related to tuberculosis, unless the high mortality from pulmonary tuberculosis argues for a special susceptibility in the leper.

An equally puzzling, if much less important, disease is the so-called "rat leprosy," an ailment of rats characterized by skin nodules containing many acid-fast bacilli, which also appear to defy cultivation. Leprologists refuse to admit, however, any further resemblance, and certainly it is true that human leprosy tissue will not infect rats, nor will any of the numerous acid-fast cultures isolated from leprous tissues.

Another disease, with likeness to both tuberculosis and leprosy, is the unnamed "skin lesion" disease of cattle. A significant affiliation with tuberculosis lies in the fact that the pathological tissue contains numerous acid-fast bacilli and the animals themselves react to tuberculosis, with resultant serious confusion in diagnosis, leading to unwarranted slaughter, as indicated at length in the papers by Crawford and Daines. The resemblance to leprosy, previously stressed by Daines, rests chiefly on histological similarity of the skin lesions.

The unique condition called Johne's disease or paratuberculosis of cattle, described in detail in this symposium by Hagan, resembles all the other diseases of this series in the two respects of causation by acid-fast bacilli, and remarkable association of these bacilli with the large phagocytic cells, or modified monocytes, to which frequent reference has already been made. Another point of contact is the fact that cattle afflicted with Johne's disease react to tuberculin produced from avian type tubercle bacilli, apparently with even greater intensity than they react to the homologous "tuberculin" produced from cultures of Johne's bacillus. Moreover, a close relationship can be demonstrated serologically. A striking difference, however, is the virtual restriction of involvement of Johne's disease to the intestine. In this disease, interestingly enough, the causal organism, visible by millions in the intestinal mucosa, also long defied cultivation, but was grown at last when a needed accessory growth factor contained in acid-fast bacilli was added to the culture media.

Of other diseases caused by acid-fast bacteria nothing further need be said, as they are too ill-defined in present-day literature for good picturization. Reference should not be omitted, however, to the great group of acid-fast bacteria of no recognizable pathogenicity, the chief representatives of which are the smegma bacilli, which have a saprophytic existence on moist cutaneous surfaces, and the great group of "grass bacilli" saprophytic on various kinds of grass. To these are being constantly added newly discovered strains from soil and sewage, which are not pathogenic for the larger laboratory animals, but appear to have limited pathogenicity for cold-blooded animals. The occurrence in grass raises a suspicion of their relation to the skin nodules of cattle, and a possible relation of some strain to the causation of leprosy is at least not ignored in all comprehensive considerations of the latter subject.

The Mycobacterial Diseases Experimentally Produced

The foregoing review brings us to the more modern period of experimental pathology. It is the latter science that has exposed the puzzles described, and only through continued progress in experiment is there prospect of their solution. The fundamental problem

is the variation in type of mycobacterial disease in different animal species, the question raised by Corper in the closing discussion of the first group of papers presented in this symposium. The same problem has been stated in different forms by other speakers in this symposium, with hypotheses for explanation. The following remarks are composed largely from the suggestions they have offered.

In analyzing the material at hand on the subject of pathogenicity, it may be well to restate certain fundamental facts with illustrations. This will be done under five headings:

1. *There is variation in the disease caused by one strain of acid-fast bacilli in different animal species.* The most familiar example is the effect of the "human type" bacillus, isolated from human pulmonary tuberculosis, on guinea pigs and rabbits. Small doses produce progressive, fatal disease in the former, and restricted lesions with regressive tendency in the latter animal. A greater range of pathogenicity is observed if the selection of animals is widened. Some years ago Vorwald injected the same dose of human type tubercle bacilli, per unit of animal weight, intravenously in a series of monkeys, guinea pigs, rabbits, dogs, cats, chickens and turtles. The result was massive caseating tuberculosis in the monkey, only slightly less intense generalizing progressive disease in the guinea pig, initially progressive but soon essentially stationary lesions in the rabbit and the dog, very slight response with early regression in the cat and chicken, and no detectable lesion in the turtle.

2. *There is variation in the disease caused by different strains of acid-fast bacilli in one animal species.* A familiar example is the effect of bovine, avian and human type tubercle bacilli and other acid-fast bacteria, as Johne's bacillus, on the rabbit. The bovine microorganism produces progressive fatal disease; some strains of the avian bacillus cause rapid generalized disease with early fatality, while other strains lead only to a restricted pathological process; the human strain with infrequent exceptions induces localized disease with little tendency to progression; and Johne's organism causes no disease at all. The organisms isolated from skin lesions in cattle, the emulsified tissues of lepers, rich in acid-fast bacilli, and the large array of saprophytic acid-fast bacilli, also cause no disease, or at the most only foreign body tubercles. The same set of bacteria injected into other animals would lead to an equally wide range, but by no means the same serial order of pathogenicity.

3. *There is variation in the disease caused by one strain of acid-fast bacilli in one animal species modified by special treatment.* The most familiar example is infection of normal and immunized guinea pigs with the same dose of a given strain of tubercle bacilli. As noted previously, an ordinary virulent human type tubercle bacillus causes progressive fatal disease when injected into a normal guinea pig. However, attenuated tubercle bacilli of but slight virulence are available, which do not set up progressive disease in the guinea pig, but do induce a protective immunity. Well-known examples of such attenuated bacilli are the R_1 bacillus of Saranac Lake and the BCG of the Pasteur Institute. If virulent human type tubercle bacilli, in a dose fatal for a normal guinea pig, are injected into guinea pigs a month or two after a preliminary inoculation with a suitable dose of the attenuated organisms, the virulent bacilli do not set up a rapidly progressive tuberculosis, as in the normal guinea pigs, but a different type of disease, of much slower course. A similar variation in virulence can be demonstrated for other acid-fast bacilli in other animals, as, for example, bovine type tubercle bacilli in normal and immunized rabbits.

4. *There is variation in the disease caused by one strain of acid-fast bacilli in one animal species unmodified by special treatment.* All investigators in tuberculosis know that individual differences occur within a single animal species in respect to resistance to infection with tubercle bacilli. The well-known experiments of Lewis and Wright years ago proved that this variation was on a genetic basis. More recently Lurie, as he reported in this symposium, has shown that rabbits are similarly variable, breeding true as respects susceptibility through successive inbred generations. Indeed, as he pointed out, the disease in the most resistant strain of rabbit departs so far in character from disease in the susceptible strains as to remind one of infection of immunized rabbits, or even a different animal species entirely.

5. *There is variation in the disease caused by one strain of acid-fast bacilli, modified by special treatment, in one animal species.* This is the most recent discovery in the investigation of diseases caused by acid-fast bacteria, and in the minds of many investigators holds the key for the whole problem of variable pathogenicity. The pioneer studies of Petroff and the recent extensive, illuminating investigations of Smithburn and Sabin have furnished an entirely new approach to the problem. A few illustrations will suffice. A culture of tubercle bacilli isolated from a chicken suffering from avian tuberculosis and inoculated into another chicken causes tuberculosis in the second chicken, which may or may not be as severe and progressive as in the first chicken. If, however, the culture is planted on certain media, colonies of two different types develop, commonly designated as "rough" and "smooth," together with colonies of intermediate character, which apparently represent mixtures of the two individual types. The two new strains

thus "dissociated," when inoculated in equal dosage into chickens, produce very different effects, the one type being highly virulent and the other of relatively low virulence. Various media seem suitable for this differentiation of strains from an original single strain, but the results are inconstant. Apparently the loss of virulence that occurs with many cultures on repeated laboratory transfer is a manifestation of the same phenomenon. Smithburn has recently been able, however, to produce at will these dissociation modifications of strains of human and bovine origin merely by controlling the reaction of the culture medium. The organisms grown at pH 6.0 tend to be attenuated and those grown at pH 6.8 of high virulence within a single animal species. As Sabin has described clearly in her paper in this symposium, out of an original virulent bovine type culture producing rapid diffuse tuberculosis of the "soft" type in rabbits, an attenuated "dissociated" strain can be isolated by cultivation at an appropriate reaction, which will produce only discrete "hard" tubercles in rabbits. Sabin and Smithburn have called attention to the similarity of the "hard" tubercle produced by an attenuated dissociated strain of the avian type bacillus in a susceptible animal, like the rabbit, and the "hard" tubercle produced by the corresponding virulent dissociated strain of the same bacillus in a relatively insusceptible animal, like the dog. They compare the apparent reduction in virulence in the different animal species to the reduction of virulence directly induced artificially by cultivation on suitable media. Sabin concisely expressed it thus: "A species of animal which is highly resistant to a strain of acid-fast organisms virulent to some other species degrades the bacilli to the level of producing only hard tubercles." In support of this view is Smithburn's observation that bacilli isolated from a resistant animal after inoculation with a culture highly virulent for another species of animal show certain morphological changes from the original bacilli and from those isolated from a susceptible animal. Further work is needed, however, to prove whether or not these changes are associated with measurable and lasting loss of virulence for the susceptible animal.

It will be recalled, in this connection, that there is much evidence, such as that recently submitted by Jensen and Frimodt-Möller, indicating that animal passage may occasionally result in dissociation of the injected tubercle bacilli into strains of unchanged and increased virulence. The facts recorded, if finally confirmed, may explain in modern terms the well-known phenomenon of increased virulence with animal passage.

The Variables in Mycobacterial Disease

In reviewing the facts just outlined the reader must be struck by the lack of constants in the problem of pathogenicity. Both the infecting bacillus and the infected animal are variables. The resultant disease represents the interplay of two inconstant forces. Obviously neither the bacillus nor the animal controls the situation. Moreover, each modifies the other, if we accept all the results just outlined. The bacillus may change the character of the animal by "immunizing" it, and possibly the animal changes the character of the bacillus by "degrading" it, on the one hand, or separating out a strain of increased virulence, on the other.

A simple illustration raises a major problem. A bacillus isolated from a case of human pulmonary tuberculosis produces progressive disease in the guinea pig, and only little disease, and that of quite different character, in the rabbit. Why is the disease so restricted in the latter when the bacillus is so virulent for the former animal? It is not because the bacillus can not multiply in the rabbit. In fact Lurie has shown that at first it multiplies very rapidly there. But the initial multiplication itself seems a favorable factor for the rabbit, because rapidly the latter animal changes in character and becomes "immune" or at least of exalted resistance to further multiplication of the bacillus. On the other hand the bacillus itself may have suffered in the process, *i.e.*, been "degraded" in virulence, as suggested by Smithburn and Sabin. Have we, then, two explanations of immunity, one postulating a specific increase in resistance of the animal, and the other a specific decrease in virulence of the bacilli, or are these merely two forms of expression of the same fact?

In considering this we should return to one of the fundamentals in the pathology of the several diseases under consideration in this symposium, and recall that pathogenicity is a function of the monocyte and its derivative the epithelioid cell, whatever be the animal concerned. Within wide limits it appears to be true that the animal is as resistant as his mononuclear phagocytic cells. Animals whose monocytes are favorable to the growth of acid-fast bacilli, as White has repeatedly pointed out, are susceptible animals. Animals, on the contrary, whose monocytes do not support the growth of these bacilli, are resistant animals. The statements made for the resistance of animals in preceding paragraphs hold equally well for the resistance of the mononuclear phagocytes of those animals. As Sabin has written concisely in her paper, "in the lesions produced by avirulent or attenuated organisms it is probable that the bacilli are killed in the monocytes, while with the virulent strains, on the other hand, the monocytes are killed by the bacilli."

That the monocytes may change in a single animal infected with a single strain of bacilli, permitting rapid growth at first and little growth later, has been shown by Lurie. As he points out, the longer the dis-

ease produced by avian type tubercle bacilli lasts in the rabbit, the more it assumes the character of tuberculosis produced by bacilli of mammalian origin. At first it is of the "Yersin" type, a diffuse infiltration of mononuclear cells stuffed with acid-fast bacilli. Later the diffuse process disappears and nodular ("hard") tubercles with a necrotic center remain, formed essentially of mononuclear cells with few bacilli.

In the observations of Sabin and Lurie the nature of the epithelioid cell of tuberculosis and other diseases of mycobacterial origin seems apparent. Sabin has shown by experiment that through phagocytosis and dispersion of the lipid of these bacilli the monocyte becomes an epithelioid cell. Lurie has observed the epithelioid cell to be a phagocytic cell that has killed a large number of bacilli. In brief the epithelioid cell would seem to be one in which accumulation of bacilli first occurred, followed by their destruction and a characteristic dispersion of their ingredients.[3]

The Constants in Mycobacterial Disease

This discussion of the variables of tuberculosis and allied diseases brings us to our final consideration, the constants. Little enough is known about them, in spite of extended research. They are the chemical constituents of the reacting components in the disease, *i.e.*, the acid-fast bacilli and the cells accumulating about them. Of the essential distinctive chemistry of the cells, we know practically nothing. We must dismiss that subject from our consideration, not because of its lack of importance, but from almost complete lack of evidence upon it. On the chemistry of the acid-fast bacilli we are much better informed, although here, too, the gaps in our knowledge are immense. For years the National Tuberculosis Association has promoted research designed to discover chemical differences, accounting for variable pathogenicity, in the group of mycobacteria, and in spite of the gaps much valuable information has been obtained. It should be noted that the mycobacteria used in this big comparative study were all grown on the same medium and handled in the same way, in order to eliminate as much bacterial variability as possible.

One of the most distinctive features of the chemistry of the acid-fast bacteria is their common possession of unusual lipids, which apparently are not found in animals or other microorganisms thoroughly studied, like yeast. The high concentration of these substances in the bodies of the bacilli of the different types is also distinctive. It must also be significant that as a general rule the proportion of lipid to total body weight is highest in the pathogenic organisms.

The lipids of the acid-fast bacilli have been grouped by Anderson in three classes, phosphatides, fats and waxes. All are distinctive. Unusual features are their content of a liquid saturated fatty acid of high molecular weight, not encountered elsewhere, and the presence of distinctive carbohydrates. The fat-like substances do not contain glycerol, like true fats, but, instead, the disaccharide trehalose.

It is noteworthy that the phosphatides and certain fatty acids derived from them, as shown by the cooperative work of Sabin and Anderson, are active stimulants for monocytes and the development of epithelioid cells therefrom. Typical epithelioid tubercles, indistinguishable from those produced by dead tubercle bacilli, or early ones caused by living bacilli, can be induced at will in experimental animals by the lipid alone. Naturally one at once tries to link this fact with the pathogenicity of the organisms. The phosphatides seem to be characteristic of the group rather than any specific strain, and it may indeed be true that the chronic epithelioid cell reaction in all the diseases here considered is due to the mutual possession of large quantities of this phosphatide. It is interesting that Anderson has found that although quantitative differences in phosphatide content obtain among various strains of tubercle bacilli, qualitatively the latter are alike. The hydroxy acids combined within the wax-like phosphatides differ, however, with the different types of acid-fast bacteria, and so do the combined carbohydrates. The latter, as derived from the pathogenic human and avian types of bacilli and the non-pathogenic timothy grass bacilli, are entirely unlike.

Again in the great carbohydrate fraction uncombined with lipids, certain possessions in common are apparent, as brought out by Heidelberger and Menzel. Glycogen appears to be distributed through the group, as well as certain other serologically active and inactive polysaccharides. It was naturally hoped that serological distinctions, comparable to the well-known differences between types of pneumococci responsible for pneumonias of varying severity in man, might be discovered, but the most careful effort has failed to demonstrate any qualitative distinction between the polysaccharides of the bovine and human type of tubercle bacilli, although the disease produced by these two types in man is quite different. Thus the rôle of

[3] There are difficulties in the way of this view. In the epithelioid tubercles of the lymph nodes of man, no matter how young these tubercles are, acid-fast bacilli are very rare. It may be true, however, that a continuous process of accumulation and destruction goes on, so that but few bacilli are found at any given time. Moreover, we can not overlook the possibility that tubercle bacilli, such as those described by Kahn, may be present in epithelioid cells and never mature to the point where they give evidence of their presence by stains for acid-fastness. In this connection it is well to recall also that by far the largest accumulations of tubercle bacilli found in human tuberculosis are not in the epithelioid tubercles at all, but occur as free-growing masses in softened caseous debris.

carbohydrates in the disease process is uncertain, although they have definite toxicity for certain tissue and blood cells, and thus are accountable for some of the anatomical damage and probably for certain of the symptoms of disease.

In the protein fraction of the mycobacteria, as indicated by Seibert in this symposium, important differences are becoming increasingly evident. And just as the lipids appear to be responsible for certain of the more chronic anatomical features of the disease, so the proteins appear to be the cause of some of the acute responses. Indeed just as certain features of the disease can be reproduced by the lipid alone, so certain other elements of the pathological process can be constantly called forth by the protein. Experimental evidence would seem to indicate that the serous and much of the cellular elements of the exudations of tuberculosis are due to the protein, or are caused by derivatives of the bacillary proteins. The latter are intimately related to the whole phenomenon of hypersensitiveness. Of themselves they readily induce a type of hypersensitivity, and in hypersensitive animals, in exceedingly minute quantity, they cause severe reactions. It is notable that a great distinction holds among the mycobacterial diseases in respect to hypersensitiveness. The mammalian forms of tuberculosis are characterized by marked hypersensitiveness, and avian tuberculosis and Johne's disease by hypersensitiveness of lesser degree. Curiously, animals affected with Johne's disease react to the tuberculin, which in the final analysis means the protein, prepared from avian type tubercle bacilli more intensely than to tuberculin from Johne's bacillus itself.

In leprosy, up to the present time, hypersensitivity has not been demonstrated. In our present lack of certain information on the bacterial cause of leprosy the problem can not be investigated in the same way as tuberculosis. Proteins are easily obtained from the avirulent acid-fast bacilli so far isolated from leprous tissues, but they do not cause specific tuberculin-like reactions in lepers, as shown in a recent extensive study by McKinley and his colleagues in the Philippines. Henderson has compared these proteins with each other and with the proteins of other acid-fast bacilli by serological methods and found certain similarities and certain differences, the theoretical importance of which may possibly be great, although at present uncertain.

Cattle suffering from mycobacterial "skin lesions" are hypersensitive, but strangely enough appear more sensitive to tuberculin produced by human and bovine types of tubercle bacilli than to the tuberculin, or, in other words, protein of the skin lesion organisms themselves, an anomaly reminding one of the relation between Johne's disease and the avian type of tubercle bacillus.

Seibert, Heidelberger and Crawford, as noted in this symposium, as well as others, have discovered distinct and apparently constant differences in the proteins produced by different strains of acid-fast bacilli, using serological methods and the skin reaction in infected animals as criteria for identity or distinction. By these methods the proteins of the human and bovine type bacilli appear practically indistinguishable, while that of the avian bacillus is readily recognized as different. Other acid-fast bacilli, such as the timothy grass bacilli, the so-called leprosy bacilli isolated from leprous tissue, but avirulent, and the tubercle bacilli from cold-blooded animals, all show easily detectable differences. It is noteworthy, however, that they also reveal certain similarities. Indeed, there is a certain amount of similarity in the proteins of the entire mycobacterial family, as shown by cross precipitation within a certain range between the various proteins as antigens and the various antisera. Presumably, as emphasized by Seibert, Feldman and Crawford in this symposium, the overlapping sensitization, as demonstrated by the tuberculin type of test, is dependent on an underlying common possession of certain chemical groups in the antigens concerned. Indeed, Seibert has now sufficiently investigated the chemical composition of the proteins concerned to be certain of definite similarities and variations demonstrable by chemical analysis.

Thus in final analysis we seem concerned with certain biologically active chemical substances capable by themselves of inducing characteristic features of disease, differing from organism to organism, and yet with certain similarities withal. Studied intimately they are seen to exert specific effects on the great defensive cell of the body, the mononuclear phagocytic cell or monocyte. This can be shown not only in the intact animal, as described in this paper, but directly by interaction of both chemical and monocyte as described by Aronson, the one removed from its parent substance, the acid-fast bacillus, and the other explanted from its parent substance, the animal body.

SUMMARY

1. Tuberculosis, leprosy, the "skin lesion" disease of cattle, Johne's disease, rat "leprosy" and a series of ill-defined ailments of rodents, cold-blooded animals and birds, constitute a group of diseases of spontaneous natural occurrence, with two distinctive features in common: (1) causation by mycobacteria, *i.e.*, bacteria distinguished by the staining property of acid-fastness, due in turn apparently to mutual possession of certain chemical substances, and (2) a host response characterized by extensive proliferation and accumulation of large mononuclear phagocytes, or monocytes, and their development into "epithelioid" cells.

2. In addition to the naturally occurring mycobacterial diseases, just listed, a wide variety of disease processes caused by acid-fast bacteria can be induced experimentally by infecting different animals with the various bacilli of the group. Variations as follows can be produced at will:

(a) From one strain of mycobacteria in different animal species.

(b) From different strains of mycobacteria in one animal species.

(c) From one strain of mycobacteria in one animal species modified by immunization.

(d) From one strain of mycobacteria in one animal species with genetic variability in susceptibility.

(e) From the dissociated elements of one strain of mycobacteria in one animal species.

Thus a wide variety of mycobacterial diseases occurs as a result of animal and bacterial variability.

3. Although host and infecting agent are variables, constants occur in the chemical constituents of the two. Of the chemistry of the cells of the animal body which accumulate in the characteristic lesions of this group of diseases, little of significance is known. In contrast, much information is available on the chemistry of the artificially grown mycobacteria. Lipids, proteins and carbohydrates are distinctive, qualitative and quantitative differences being detectable within the group. The lipids act as stimulants for the large mononuclear phagocytic cells, and the proteins also call them forth in the acute processes of the diseases concerned. In general the inflammatory exudations and the toxic necroses seem to be the result of protein action, particularly after "hypersensitiveness" is induced in the course of the disease, while the chronic changes are due in large measure to the bacillary lipids. The ultimate "epithelioid" appearance of the characteristic cells making up the lesions of the several diseases concerned appears to be the result of destruction of acid-fast bacilli within them and cytoplasmal dispersion of their constituent lipids. Some of the carbohydrates as well as proteins appear to be toxic for animal cells.

4. With these facts at hand the great variability of mycobacterial disease is understandable as the result of interplay of variable bacteria and variable animal cells, each with its individually characteristic content of biologically active chemical constituents. This can be shown readily for the experimental disease in the laboratory, and the facts brought to light suggest plausible explanations for the great variability of spontaneous mycobacterial disease in nature.

OBITUARY

DAVID WILLIAM MAY

IT is with a deep sense of loss that his former colleagues record the death of David William May, retired director of the Puerto Rico Experiment Station of the United States Department of Agriculture. He died on December 12, 1937, at Mexico, Mo., and was buried in Lexington, Ky.

Director May was born in Platt County, Mo., on April 22, 1868. Educated in the schools of that state, he received his bachelor's and master's degrees from the University of Missouri in 1894 and 1896, respectively. He spent three years as assistant agriculturist at the Missouri Experiment Station and two years in Washington as assistant in agriculture in the United States Department of Agriculture. He was appointed animal husbandman at the Kentucky Experiment Station in 1901, and three years later became director of the Puerto Rico Experiment Station, in which position he continued for twenty-six years.

Director May came to Mayaguez only two years after the station had been established by act of Congress in 1902; at that time he was but thirty-six years old. He gave to the station the most productive years of his life, and his impress will remain for many years. He secured appropriations for and supervised the erection of the station laboratory and office buildings, developing an architecture which is constantly admired for its beauty as well as its adaptability to its tropical setting and climate. The lands operated by the station were extended to 420 acres. He and his staff assembled what has been stated to be the largest collection of tropical plants in the Western Hemisphere.

Director May did much to build up and diversify the agriculture of Puerto Rico and put it on a more self-sustaining basis. He also helped to devise and introduce improved methods, and he shared in the eventual development of the station as a tropical outpost for the United States Department of Agriculture. He served for many years as a trustee of the University of Puerto Rico, and it was primarily due to his initiative that the College of Agriculture and Mechanic Arts of the university was founded and located at Mayaguez contiguous to the station.

Mr. May's colleagues feel that no written word can be an adequate tribute to his accomplishments and personal qualities, but that the beautiful gardens and buildings of the experiment station itself will constitute a fitting memorial to him.

CARMELO ALEMAR
ATHERTON LEE

RECENT DEATHS AND MEMORIALS

DR. HERMAN SCHLUNDT, chairman of the department of chemistry of the University of Missouri, died on December 30 at the age of sixty-eight years.

DR. LAWRASON BROWN, of the Trudeau Sanitarium, Saranac Lake, N. Y., a leading specialist on tuberculosis, died on December 26 at the age of sixty-six years.

DR. EMMET RIXFORD, surgeon of San Francisco, past president of the American Surgical Association, died on January 2. He was seventy-two years old.

MISS CARLOTTA JOAQUINA MAURY, formerly paleontologist for the Brazilian government and from 1912 to 1915 professor of geology and zoology at the Huguenot College of the University of the Cape of Good Hope, died on January 3 at the age of sixty-four years.

DR. GEORGE ALFRED BUCKMASTER, emeritus professor of physiology at the University of Bristol, previously professor of veterinary physiology at the Royal Veterinary College, London, died on December 21 at the age of seventy-eight years.

Nature reports the death of Henry Crowther, formerly curator of the Leeds Museum, on November 29, aged eighty-nine years; of Dr. A. Lodge, formerly professor of pure mathematics in the Royal Indian Engineering College, president of the Mathematical Association in 1897–98, aged eighty-three years, and of Dr. D. S. Macnair, known for his work in analytical chemistry, an inspector in charge of the scientific and technical instruction under the former Science and Art Department, on November 27, aged seventy-six years.

A MONUMENT to the memory of the late Professor Emile Roux, director of the Pasteur Institute of Paris, was unveiled at his birthplace, Confolens, on November 14, when the present director, Dr. Louis Martin, delivered an address.

SCIENTIFIC EVENTS

THE JAPANESE RESEARCH INSTITUTE OF INDUSTRY AND LABOR

THE Japanese Research Institute of Industry and Labor, supported by the Japan Science Association, is reported in the *Journal* of the American Medical Association to have decided to equip various buildings for its research work in Tokyo at a cost of 1,102,000 yen.

The institute has laboratories, a library, a museum of industry and labor, a school of industry and labor and assembly halls. There will also be laboratories for study of the prevention of occupational diseases. Equipment will be provided for the study of both the physical and the spiritual conditions necessary for efficiency in labor. It is pointed out that "however much industry is mechanized, it will be impossible to cease employing human muscular labor; furthermore, human muscles will be required to work more speedily and to be more delicate and enduring."

In these laboratories the training of muscles along these lines is to be the subject of research. An instrument is to be furnished to investigate the various phases of biologic electricity which accompany muscular exertion. In the laboratory for investigating fatigue, the chief studies will relate to nerve control. The rehabilitation of the disabled and the deformed will be undertaken by the most modern methods. The cost of living and the wages paid for labor are to be subjects of investigation. Factory sanitation and the development of the laborers' physique will be studied.

The chief of the institute will be Dr. Y. Teruoka, formerly chief of the Kurashiki Labor Research Institute, now adviser to the central government on labor problems.

THE FLOATING EXPEDITION OF THE U.S.S.R. IN THE ARCTIC OCEAN

ROTATION of the ice floe on which four Russian scientific men are drifting in the Arctic has forced Jenya Fedorov, meteorologist of the expedition, to give up measurements of magnetic variations, according to the report made to Science Service by Tass, the Soviet news agency. A radio message from I. Papanin, chief of the group, reads, "But it does not affect the other observations, in general; our specialists Shirshov and Fedorov have to work under very difficult conditions."

On May 21 Papanin sent over the radio an account of the scientific work accomplished since the expedition landed on the ice floe at the North Pole two hundred days before. It is as follows:

We have thoroughly studied the path of the ice floe from the North Pole to the coast of Greenland. We measured the depth of the ocean at 15 points and made hydrological soundings at 26 points, having taken samples of water at each point from 15 to 25 various depths.

We made several series of observations for the study of the direction and the speed of the submarine currents. Our hydrological work finally established the existence of a sufficiently abundant organic life in the central part of the Arctic Ocean.

During our stay on the ice floe we have made more than 100 astronomical observations. These will make it possible to trace precisely the entire path of the drift and to learn the laws governing the movement of the ice floes in the Central Polar Basin.

In general, our program of scientific observations has been extensive. We hope that 35 definitions of magnetic elements, 13 observations on gravitation, several series

of observations of the electric condition of the atmosphere will not prove useless.

We are aware that our regular meteorological observations are received with great interest by scientific institutions on the mainland. We note weather changes every two hours and send the results four times a day to the south.

We watch the Polar Ocean attentively. We have gathered substantial scientific material and many scientists will now obtain reliable data on the entire area of our drift from the North Pole to the final point.

Describing the taking of soundings, Papanin reports that members of the expedition use a rope to connect the small sounding tent to their camp so as not to lose time looking for it in the Polar night. He says: "Along this rope we travel safely in any weather. Without this it would be rather difficult to find one's bearings in a snowstorm. Once Krenkel and I lost our way and while being within a few steps of our tent, we could not find it for quite a long time."

ANNUAL REPORT OF THE COMMONWEALTH FUND

THE report of the Commonwealth Fund which has just been issued announces that during the year two gifts had been made by Edward S. Harkness, president of the fund. These gifts bring the total endowment of the fund to the sum of $50,000,000. The first gift of $3,000,000 is to be used initially in support of the rural hospital program, thus releasing income from the original endowment for other philanthropic purposes of the fund. The provision for this special program may be said to mark the definite continuance by the fund, after extended experimentation, of the organization of community hospital service in small towns and surrounding rural areas as an important aid to health. The second gift, of $5,000,000, is intended for the present to provide increased income for grants to medical research and to certain phases of medical education.

In addition to grants previously made that are being continued, the following new grants have been made during the past year:

To Irvington House, Irvington-on-Hudson, New York, for the bacteriological and clinical study of rheumatic fever in children, with special reference to the possible rôle of the hemolytic streptococci.

To Harvard University Medical School for the production and shipment, under the direction of Dr. Hans Zinsser, of an immune serum against typhus fever to be tested in epidemic areas in the Balkans and North Africa.

To the Washington University School of Medicine, St. Louis, for the comparative study of certain virus infections as a further step toward better knowledge of the virus of trachoma, and for testing methods of treatment suggested by the work already done on this virus.

To the New York University College of Medicine for the study of such functional disturbances as pre-eclamptic toxemia, eclampsia, and the pernicious vomiting of pregnancy, and of communicable infections associated with childbirth and abortion.

To the Johns Hopkins University School of Hygiene and Public Health for a longitudinal study of the incidence of certain chronic diseases in a limited community.

To the Johns Hopkins University School of Medicine for a study of the nature and mechanism of virus infection of the central nervous system in poliomyelitis.

To Harvard University Medical School for a group of studies on clinical and immunological phases of poliomyelitis.

The Commonwealth Fund Fellowships for British students this year include for the first time three fellows appointed from the Home Civil Service of the British Government. Only men of mature years already well established in the government service are eligible for appointment. They will come to America, as do the service fellows from outlying parts of the British Empire, for technical study directly connected with their field of work, but will spend the year traveling wherever their inquiries may lead them and will not be attached to any university.

THE COLUMBIA UNIVERSITY SCHOOL OF MEDICINE

A GIFT of $180,000 has been made by the Martha M. Hall Foundation to the Columbia University School of Medicine, to be applied to new laboratories for graduate medical education, the construction of which has just been completed. Three additional gifts amounting to $47,250 have been announced.

The Martha M. Hall Foundation, of which James Jay Morgan is president, was founded by the will of Miss Martha M. Hall in memory of her father, William Henry Hall, "for the benefit and advancement of public and private charitable and scientific objects and purposes."

The appropriation supplements grants of $290,000 from the Commonwealth Fund toward the building program, and $50,000 from the Josiah Macy, Jr., Foundation toward the research and teaching program. "Better, rather than more, physicians" is the aim of the program, which provides for continued education of physicians in practice and adequate training of specialists, and affiliates many hospitals of the metropolitan area.

The new addition, comprising ten stories on the former six-story extension of the west wing of the building of the School of Medicine at 168th Street and Fort Washington Avenue, will be occupied within the next few weeks by research laboratories for graduate students working in the basic medical sciences of anatomy, physiology, pathology, bacteriology and

chemistry, and will also house the Crocker Institute for Cancer Research.

Dr. Willard C. Rappleye, dean of the School of Medicine, has made the following statement:

Besides permitting an increase in the enrolment of candidates for the highest medical degree, doctor of medical science, the new laboratories will provide opportunities for a considerable number of others who, in the course of their medical training, wish to work on special problems requiring such laboratory facilities.

The new building, which will serve as a nucleus of the graduate program of the school, will accommodate residents in hospitals affiliated with the university as well as those who are working in the hospitals of the Medical Center. In view of the changes which are taking place in the requirements for specialization, it is increasingly important for specialty services to provide time during the residency period for training such as this school will shortly be prepared to offer.

During the past few years there has been a noteworthy increase in the number of graduating students who plan to spend longer periods than heretofore in hospital work before entering medical practice. The undergraduate student of to-day is looking further ahead and seeking opportunities for a more extensive and complete training in graduate fields. This is particularly true of those who plan to enter some special field in medicine but applies also to those who expect to become general practitioners.

Within our own organization certain changes have been made in the internship and residency programs in order to keep pace with this growing trend. These changes include lengthening of the term of hospital residencies in certain instances, the introduction of more conferences and seminars for the benefit of the hospital house staff, and provision for greater freedom on the part of the resident to pursue studies in some special field of laboratory and investigative work.

THE SAVANNAH MEETING OF THE ELECTROCHEMICAL SOCIETY

THE spring meeting of the Electrochemical Society will be held at the Hotel De Soto, Savannah, Ga., from April 27 to 30.

There will be two main sessions: Thursday morning will be devoted to a symposium on "Physical Chemistry in the Pulp and Paper Industry," which will be presided over by Charles Carpenter, of the Industrial Committee of Savannah, Inc. The topics which will be treated in this session are: "The Chemistry of Pulping of Wood," "The Physical Chemistry of Sizing and Filling of Paper," "The Chemistry of Woodpulp-Bleaching," "The Mechanism of Cellulose Reactions," "The Chemistry of Chlorine and Hypochlorites," etc.

A second symposium on "Industrial Electro-Osmosis" will be held on Saturday morning, when Professor H. Jermain Creighton, of Swarthmore College, will preside. The Friday morning session will be devoted to papers on electrodeposition and miscellaneous subjects.

Dr. Charles H. Herty, who has been conducting experiments in his Pulp and Paper Laboratory at Savannah for the past five years, will deliver the fifth Joseph W. Richards memorial address on Thursday evening. The discussion at the luncheons will be under the direction of the divisions of the society. The luncheon on Thursday will be devoted to "Electrothermics"; on Friday to "Electrodeposition," and on Saturday to "Electronics."

Arrangements have been made for members of the society to visit Dr. Herty's laboratory and the industrial plants in the Savannah district, including the Southern Cotton Oil Company, the Union Bag and Paper Corporation, the Reliance Fertilizer Company and the Savannah Sugar Refining Corporation.

RETIREMENT OF THE DIRECTOR OF THE NEW YORK STATE EXPERIMENT STATION AT GENEVA

THE fifty-sixth annual report on the work of the State Experiment Station at Geneva has been issued. This is the last report to be prepared by Dr. U. P. Hedrick, who will retire on January 15, having reached the age of sixty-eight years. He has been a member of the staff for more than thirty years, becoming director of the station in 1928.

Dr. Hedrick is succeeded by Professor Percival J. Parrott, entomologist, since 1929 vice-director of the station. Dr. Parrott will be the seventh director of the experiment station since its opening fifty-five years ago.

The report covers the activities of the experiment station for the fiscal year ended June 30, 1937, and in addition to the sections dealing with the scientific work of the eight research divisions, contains a financial statement and a list of all publications prepared by members of the staff during the period covered by the report.

In view of this being his final report as director, Dr. Hedrick takes occasion to review particularly developments which have marked the nine years of his administration. Among the items discussed are the reorganization of the research program, including the establishment of new divisions of vegetable crops, plant pathology and seed investigations; the erection of a new laboratory building and new greenhouses; celebration of the fiftieth anniversary of the station; and increases in the staff appropriations, fellowships and cooperative arrangements for experimental work.

Under the administration of Dr. Hedrick improvement in the appearance of the grounds was made possible very largely by labor supplied through various relief agencies and by donations of plants, trees and

shrubs by nurserymen. Commenting on this, he says in part, "Primarily the desire was to make the grounds more presentable, but a secondary object, and one which has turned out to be quite as valuable as the first, was to plant trees, shrubs and flowers, so that all lovers of plants and those who sell plants could come to the station to study varieties, to learn what species and varieties thrive best, and to give the plant pathologists and entomologists of the station an opportunity to study the insect pests and diseases of ornamentals."

SCIENTIFIC NOTES AND NEWS

THE gold medal of the American Institute, New York City, has been awarded to Dr. William Crocker, director of the Boyce Thompson Institute for Plant Research at Yonkers, N. Y., "in recognition of his contribution to knowledge of life processes in plants and for his unique leadership in the organization of plant research." This medal is given to organizations or individuals for distinguished contributions to the advancement of natural science "which have a broad incidence on human welfare."

DR. FRANK J. TONE, president of the Carborundum Company, Niagara Falls, N. Y., was presented with the William H. Perkin Medal for 1938 of the American Section of the Society of Chemical Industry at a joint meeting of the section with the New York Section of the American Chemical Society at the Chemists' Club on January 7. The medal was awarded for "valuable work in applied chemistry, including the development of abrasives and refractories." The presentation speech was made by Professor Marston T. Bogert, of Columbia University, past president of the American Chemical Society. Dr. Carl G. Schluederberg, vice-president of the Ford Instrument Company, Long Island City, spoke on "The Life and Accomplishments of the Medalist." Dr. James G. Vail, of Philadelphia, chairman of the American Section, presided at the meeting.

A CONGRESSIONAL MEDAL "for scientific accomplishment unequalled in polar exploration" will be presented to Dr. Thomas C. Poulter, director of the research foundation at Armour Institute of Technology, at a dinner given in his honor on January 19. Dr. Poulter was senior scientist and second in command to Rear Admiral Richard E. Byrd on the second Byrd Antarctic expedition, which left the United States in October, 1933, and returned in May, 1935. The medal will be presented by Governor Horner, and Rear Admiral Byrd will speak.

DR. H. C. SHERMAN, Mitchill professor of chemistry at Columbia University, was presented at a luncheon given by the Associated Grocery Manufacturers of America on December 28 with the 1937 award—a scroll given annually for "the most outstanding contribution to the industry." The presentation was made by Dr. John L. Rice, city health commissioner.

A BANQUET was given on January 2 in Dallas, Texas, in honor of the eightieth birthday of Thomas Ulvan Taylor, dean emeritus of the College of Engineering of the University of Texas.

THE library of the School of Medicine of Tulane University of Louisiana, New Orleans, was named in honor of Dr. Rudolph Matas, emeritus professor of general and clinical surgery at the university, at ceremonies that were held on November 29. Tribute was paid to his years of service to the university and to his constant interest in the development of the library. The occasion also marked his seventy-seventh birthday, which occurred on September 12. The Orleans Parish Medical Society devoted its bulletin on December 6 to Dr. Matas in recognition of the dedication of the library at the medical school and to mark the presentation for the second time of the Rudolph Matas Vascular Award, created by the Violet Hart Fund. Professor Reynaldo dos Santos, of Lisbon, received the medal.

AN award of $1,000 and a medal has been presented to Professor Julius Wagner-Jauregg, of Vienna, by the Committee on Research in Syphilis, New York City. Professor Wagner-Jauregg, now eighty years old, is critically ill at his home in Vienna. The award was made in recognition of work on the malaria treatment of syphilis, for which he received the Nobel prize in 1927. The Committee on Research in Syphilis was organized in 1928 by a group of laymen, acting in cooperation with the American Social Hygiene Association, to subsidize and develop clinical and laboratory research.

Nature states that it is proposed to present Sir Arthur Keith with a bronze bust of himself in appreciation of his work in the fields of anatomy, embryology and anthropology. Sir Arthur wishes to hand over the bust to the keeping of the Royal College of Surgeons, should it be found possible to secure it. The sum of £150 is required to purchase the bust, and contributions are invited towards this amount. Sir Arthur Keith has been invited by the college to give a lecture on the ancient types of man which were discovered in Palestine some years ago. This lecture will be given on February 14, and it is proposed to present him with the bust on that occasion.

PROFESSOR GEORGE A. BAITSELL, of Yale University, was elected president of the Society of Sigma Xi at the Indianapolis meeting. Professor Harlow Shapley, of Harvard University, was elected a member of the executive committee. Professor George B. Pegram, of Columbia University, was elected treasurer.

DR. MARK H. INGRAHAM, professor of mathematics at the University of Wisconsin, has been elected president of the American Association of University Professors to succeed Dr. Anton J. Carlson, of the University of Chicago.

DR. EDWARD SAPIR, Sterling professor of anthropology and linguistics at Yale University, was elected, at the New Haven meeting, president of the American Anthropological Association. He succeeds Dr. Nels C. Nelson, of the American Museum of Natural History.

AT the Washington meeting of the Society of American Bacteriologists, Dr. Paul F. Clark, professor of bacteriology at the School of Medicine of the University of Wisconsin, was elected president. He succeeds Dr. James M. Sherman, of Cornell University. Dr. Arthur T. Henrici, professor of bacteriology at the University of Minnesota, was elected vice-president, and Dr. Ira L. Baldwin, agricultural bacteriologist at the University of Wisconsin, was elected secretary-treasurer. Councilors-at-large elected were: Dr. William C. Frazier, of the University of Wisconsin, and Dr. Rebecca C. Lancefield, of the Rockefeller Institute for Medical Research.

PROFESSOR E. A. MILNE has been elected president of the London Mathematical Society; Professor G. B. Jeffery, Miss M. L. Cartwright and J. Hodgkinson have been elected vice-presidents.

DR. ARTHUR O. LOVEJOY, for twenty-seven years professor of philosophy at the Johns Hopkins University, will retire from active teaching in June. Dr. Lovejoy is lecturing at Harvard University during the current academic year.

DR. MORRIS RAPHAEL COHEN, who recently retired, after serving for thirty-five years, from the professorship of mathematics and philosophy at the College of the City of New York, has accepted an appointment as professor of philosophy at the University of Chicago. He will give courses only in the spring quarter. This year he will conduct a seminar on logical theory, and in 1939 will be in charge of a seminar on social philosophy. He was a visiting professor at the university in the summer of 1923.

DR. RALPH L. FERGUSON, formerly of the department of pathology of the School of Medicine of the Ohio State University, has been appointed associate professor of bacteriology at the School of Medicine of Loyola University, Chicago.

DR. DONALD C. BOUGHTON, of the Rockefeller Institute for Medical Research, has been appointed assistant professor of zoology and poultry husbandry at the University of Georgia.

DR. EUGENE C. AUCHTER, assistant chief of the Bureau of Plant Industry, has been made chief of the bureau, succeeding Frederick D. Richey, who resigned recently to engage in professional corn breeding. From 1912 to 1917 Dr. Auchter was a member of the West Virginia Experiment Station, and from 1918 to 1928 head of the department of horticulture at the University of Maryland. In 1928 he became head of the Division of Fruit and Vegetable Crops and Diseases of the Bureau of Plant Industry.

FREDERICK W. GARDINER has been appointed chief engineer for the receiver of the Interborough Rapid Transit Company. He will succeed Dr. George H. Pegram, who died on December 23, after serving as chief engineer of the Interborough since its organization.

DR. CHARLES RUSSELL, president of the State Teachers College in Westfield, Mass., has been appointed curator of the department of education of the American Museum of Natural History. He succeeds Dr. George H. Sherwood, who died last March.

DR. WALTER H. BUCHER, head of the department of geology and geography at the University of Cincinnati, has leave of absence during the present academic year. He spent the first half of the year in Europe, and plans to continue his research on land structure in Mexico during the second half.

DR. IOAN F. RADU, of the Institute of Agricultural Research of Rumania, is spending several weeks at the Citrus Experiment Station of the University of California at Riverside in conferences connected with the general subject of soil chemistry, and in regard to the field inspections sponsored by Dr. W. P. Kelley.

DR. J. OWEN PERRINE, of the American Telephone and Telegraph Company, will give, under the auspices of the Franklin Institute, on January 24 a lecture demonstration entitled "Waves, Words and Wires" in the Penn Athletic Club, Philadelphia.

DR. HAROLD G. MOULTON, president of the Brookings Institution, Washington, D. C., will address a general session of the American Institute of Electrical Engineers, which will hold its annual meeting in the Engineering Societies Building, New York City, from January 24 to 28.

DR. JOHN P. PETERS, professor of medicine at Yale University, will deliver the fourth Harvey Society lec-

ture of the current series at the New York Academy of Medicine on January 20. He will speak on "Transfers of Water and Solutes in the Body."

THE annual meeting of the Pacific Division of the American Association for the Advancement of Science will be held in San Diego from June 20 to 25, under the presidency of Dr. J. S. Plaskett, director emeritus of the Dominion Astrophysical Observatory, Victoria, B. C. The last time the division met in San Diego was in 1916. Joint sponsors of the convention are the San Diego Society of Natural History, Scripps Institution of Oceanography, La Jolla, San Diego Museum Association, Zoological Society of San Diego, San Diego State College and San Diego County Medical Society. The scientific sessions will be held in Balboa Park, and there will be exhibits, social features and excursions to points of interest. It is anticipated that there will be a registered attendance of between 700 and 800. The chairman of the local committee is Clinton G. Abbott, Natural History Museum, Balboa Park.

THE cornerstone of the new diagnostic clinic at the Boston Dispensary was laid on December 5. The clinic was dedicated on his sixty-fifth birthday to Dr. Joseph H. Pratt, professor of clinical medicine at the Tufts College Medical School. The building, which will be known as the Joseph H. Pratt Diagnostic Hospital, has been made possible by recent gifts from William Bingham, 2d, who is interested in providing a medical center at which the development of rural medicine may be planned and supervised.

A CELEBRATION marking the fiftieth anniversary of the founding of the Hoagland Laboratory of the Hospital of the Long Island College of Medicine, Brooklyn, N. Y., was held on December 17. An address was given by Dr. Oswald T. Avery, formerly a member of the department on bacteriology in the laboratory, who for the past twenty years has been associated with the Rockefeller Institute for Medical Research. The subject of Dr. Avery's address was "Bacteriology Fifty Years Ago and To-day." Dr. J. M. Van Cott, president of the board of trustees of the laboratory, introduced the speaker. In the evening a dinner was held at the Bossert Hotel. The toastmaster was Dr. Van Cott, and the speakers were William Hill, secretary-treasurer of the board of trustees of the laboratory; Dr. Benjamin White, a former associate of Dr. Avery in the laboratory, and Dr. Wade Oliver.

THE Santa Barbara Museum of Natural History, California, according to *Museum News,* plans to start construction in the near future of an auditorium building situated in the oak grove to the west of the Indian Room. The new building will be about 90 feet long and 45 feet wide. The auditorium proper will be about 72 by 45 feet and will seat 450 persons. It will be equipped with stage and projection booth, and the walls will be decorated with blankets and other ethnological material. In the basement will be a carpenter shop and other service facilities for the museum. The architectural style will conform to the rest of the museum.

DR. RUFUS C. DAWES, on December 29 in his last official act as president of A Century of Progress Exposition in 1933–34, delivered certified checks for $160,000 to seven organizations. These included one to the Smithsonian Institution for $4,800 and one for a like amount to the Yerkes Observatory. Checks for $40,000 each were given to the Chicago Park district and to the Museum of Science and Industry, and one for $32,000 was given to the Chicago Art Institute. A check for $16,000 was given to the Adler Planetarium fund.

THE fourth anniversary of the inauguration of public demonstrations in the Fels Planetarium of the Franklin Institute, Philadelphia, was reached on November 6. The total attendance during this period was 722,474, of which 199,712, mostly school children, were admitted free. The total attendance during the year ending November 5, 1937 was 148,655, while the paid attendance was 122,596, representing an increase of 27.5 per cent. over the previous year. During the fourth year 886 demonstrations were presented, an increase of 159 over the third year, and making a total of 3,841 public performances. Of these, 1,300 have been conducted by James Stokley, director of the Fels Planetarium; 1,476 by Wagner Schlesinger, assistant director; 524 by William L. Fisher; 235 by A. Clyde Schock; 230 by Wm. H. Barton, Jr.; 42 by I. M. Levitt; 18 by Dr. Roy K. Marshall, and 13 by Dr. John H. Pitman.

DISCUSSION

OUR NATIONAL MONUMENTS

THESE monuments are all of historic, scenic or physiographic meaning, taking that word in its fuller significance, present and past. Of those monuments of higher nation-wide, even international value, there are three of outstanding significance alike to the chemist, the biologist and the geologist. These are the great petrified forests of Adamana and Holbrook in Arizona, set aside through the active interest of Lester F. Ward, the Dinosaur Monument of Utah, first proposed by W. J. Holland, and Fossil Cycad National Monument, as several times mentioned in SCIENCE.

Had there been an early active interest in the East,

another most remarkable petrified forest would have been segregated, that at Shade Creek near Athens, Ohio. But beginning quite a century ago specimens were all carried away so that even twenty years ago I found no visible trace of the original forest, even with the best of local help. Nor did I learn until recently that the so-called Lesquereux specimens from the Shade Creek Forest as representing a splendid giant seed fern are conserved in the Harvard collection.

It is seen that highly characteristic fossils soon disappear, are carried off by the curious, even in thinly settled regions. Preservation of outstanding types is therefore a subject of grave concern to the public. This is often far more than a local or state issue. There is that nation-wide interest far beyond anything that can be called local or mere selfish localism. Everything has its locality—even the North Pole. We all hope to see it. But it would not mean much were it not for the South Pole which also wobbles. Or in other words, while we wish state pride in all that which is worth-while and of interest to the public, anything in the nature of local attempt at profit must become very objectionable.

Not to be misunderstood at this point, let it be noted that very many occurrences of petrified tree trunks might well be considered to have a commercial value as semi-gem stones. In such a case the constitutionality of any state laws intended to prohibit their shipment might well be called in question.

To revert to Fossil Cycad National Monument, we must insist that it has a well-nigh sublime educational significance and value. But it will require almost more than any other of the national monument series, a very special development to bring out its sheer distinctiveness. It is therefore a pleasure to note that there is the full intention in the Interior Department (the Bureau of National Parks and Monuments) to further this development with as little delay as lies within the practical and the possible.

Also, Mr. Case of the second South Dakota Congressional district introduced in the first session of the 75th Congress a bill directing the Secretary of the Interior to proceed to this development by the construction of a field museum together with other necessary improvements for preservation and display of the *in situ* cycads and other materials. This bill, *H.R. 8247*, reads as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior is hereby directed to develop the Fossil Cycad National Monument in the Black Hills of South Dakota, as created by the Proclamation of the President of the United States, October 21, 1922, by the erection of a museum suitable for the preservation and display of the rare petrified cycads of the Mesozoic deposits found in situ within the area, in keeping with their importance to science in telling the story of continental habitation through the development of plant life, and in keeping with the general interest in the beauty of the specimens there found; together with a caretaker's and visitor's lodge, water supply, trails from the nearest highway, suitable monument boundary markers, and such other improvements as he shall deem necessary: *Provided,* That the future care of the monument shall be under the jurisdiction of the Superintendent of the nearest National Park.

SEC. 2. For carrying out the purposes of this Act there is hereby authorized to be appropriated an amount not exceeding $95,000.

It is desired to record here a personal opinion or even serious objection to the proviso which ends the above bill because it would tend to needlessly and wrongly embarrass the Secretary of the Interior under many and important circumstances which could arise. Moreover, the proviso is rather needless because the Secretary of the Interior will already have the power to take such an indicated course if he so desires; but to limit him thus is against the national, even international values involved if we count the centuries through. Therefore, I would greatly desire to see substituted for the Case Bill the following which I have submitted to many of the Senators without raising a single adverse criticism and with indeed very much of attention and friendly response:

An Enabling Act of Congress purposed to aid the *National Park Service* under the *Direction* of the *Secretary* of the *Interior* in *Adequately Developing* the unusual *Public* and *Scientific Values* of the *Fossil Cycad National Monument* of the Southwestern Black Hills, of South Dakota, as set aside by *Proclamation* of the President of the United States of America, Warren G. Harding, October twenty-first, in the year one thousand nine hundred and twenty-two, or of the Independence of the United States of America the one hundred and forty-seventh.

WHEREAS, therefore, in the first instance it having been recognized that this Monument included rarely rich Mesozoic deposits of completely petrified cycads with yet other features of great scientific interest, and the exact facts and conditions having been absolutely proven by excavations carried out on the Monument mesa itself with the aid of CCC labor and the National Park Service during the month of November, 1935, resulting in the recovery of an *in situ* collection of the cycads of a hitherto unexampled beauty and interest; and

WHEREAS, since this material requires the elaboration and display on the Monument itself as originally planned there is no longer reason for delay and there is now made available for this purpose under the direction of the Secretary of the Interior and the National Park Service as provided in the act of Congress to establish such a Service, and for other purposes (39 Stat. 535), with acts additional thereto or amendatory thereof, the sum

Ninety-five Thousand Dollars to be expended approximately as follows:

(1) For a Roadway leading in from the so-called Atlantic-Yellowstone-Pacific Highway to the Northeastern corner of the present Monument area, and thence along the site of a proposed lodge and over the main mesa by the site of the planned Field Museum to an exit on the Southwest corner, being in all a distance of about one mile and a half, the sum of seven thousand dollars.

(2) For a suitable bridge across a deep ravine best traversed by the preceding proposed highway, the sum of three thousand dollars.

(3) For the proposed guest, students and visitor's lodge, with development of water supply for lodge and museum, the sum of twenty thousand dollars (items being Water, $5,000, Lodge, $15,000).

(4) For the erection of a simple but substantial, and lasting *Field Museum* on the main Mesa front as planned, the sum of fifty thousand dollars.

(5) For preparation, installation and display of exhibit of the cycads with illustration of the meaning of the phenomena of petrification, the sum of twelve thousand dollars.

(6) For low set obelisks marking the geologic divisions and horizons about the Museum, and for the tasteful care of the immediately surrounding grounds, the sum of three thousand dollars,—the sum total provided for the several purposes enumerated in the present Act being as stated *Ninety-five Thousand Dollars;* while finally it is understood that the future care of this monument will be provided for by the monies Congress has already set aside for Parks and Monuments, or will set aside for such and related worthy purposes, it being the intent in carrying out the foregoing items of development to accentuate the museum on the mesa front and the display within it.

WHENCE, any sum left over while carrying out the lesser items enumerated in this Bill, necessary and closely estimated though they be, should be applied to the two major items (4 and 5), plainly of such significance that in the long future a larger sum of money, whether from public or private source, could well be expended upon them.

It is advised that the Monument area be eventually added to up to at least one, or better two, squares miles.

In closing these notes I wish to record a very pleasant fact indeed, one of a genuine international meaning. There lie more or less hidden in the Apennines, along the shores of the Isle of Wight, and also the Isle of Portland, and especially in the Galician Carpathians, forests of the same kind and age as that in far fuller view at Fossil Cycad National Monument; and Europeans because of their direct interest in our venture have contributed wonderful comparative materials from all these localities.

Because of such a friendly fact, such a world-wide interest in sheer ideals, does it not become rather absurd that certain of our American specimens of first importance to our greater recovered series are known to have been dragged out of view by parties possessed indeed by a frantic curiosity, but entirely and sadly ignorant of scientific values and with far less of use in view than the Etruscans had for *Cycadeoidea etrusca* over four thousand years ago? As related to the Fossil Cycad National Monument series we have also the occurrence of remarkable related types scattered about in the San Juan Basin. A large collection of these including three species is now at Yale and has been frequently mentioned in print. It is peculiarly desirable to learn the exact features of the flowers of this free-flowering group. One specimen in the hands of a local dealer appeared to have the floral features. It was promised for use in research, but was subsequently stubbornly withheld. One could wish that research might not encounter anything like that! Clearly, no individual in this or any country should be allowed to sequester materials valuable in the study of paleontology which he is utterly unable to use or understand; and it is greatly to be doubted if the state or province should have an undisputed right to do so either. Fortunately, there are always many who in addition to curiosity have the boundless, wonderful wish to be useful; many who are ever ready and anxious to aid in the assemblage of unusual paleontologic materials and data. The principle of eminent domain carried to its fullest and logical conclusion must ever protect the interests of all the people of a great nation now and for the far future. The task of delimiting and obelisking featurewise an ocean-bound country can not be else than long. Let no one mistake the real values, and let simplicity and economy ever prevail.

G. R. WIELAND

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THE LOWER SONORAN IN UTAH

READERS of Professor Cottam's[1] interesting article on the effect of the heavy frost in January, 1937, may be pleased to know that, after all, Utah is in no danger of losing her claim to the Lower Sonoran life zone.

Stimulated by the above-mentioned article and having an opportunity to drive through southwestern Utah in August, 1937, the writer took note of the condition of the Lower Sonoran vegetation, both in the region around St. George and in a considerable area on the alluvial fans west of the Beaver Dam Mountains.

Particular attention was paid to four typical Lower Sonoran plants—creosote bush, *Larrea divaricata;* mesquite, *Prosopis chilensis;* burro weed, *Franseria dumosa;* and desert willow, *Chilopsis linearis.* All these species showed the effects of the frost, but not

[1] W. P. Cottam, SCIENCE, 85: 563–564, June 11, 1937.

a single plant was noticed which was completely dead. Numbers of plants of *Larrea* and *Prosopis* had been frozen to the ground, but all these observed were sending forth a vigorous growth of shoots from the base which were already 10 to 50 centimeters tall. The wholesale destruction of the vegetation implied by Professor Cottam's observations of "brown water-soaked cambium layers even at the crown of most shrubs" was not evident along any of the forty or fifty miles of road traveled by the writer in this life zone. Also the bronzing of the junipers in the Upper Sonoran zone noted by Professor Cottam had disappeared, at least in the Beaver Dam Mountains and the regions of Zion and Bryce Canyons.

Interesting was the evident variation in resistance to the frost of plants even of the same species. Some of the difference in effect was doubtless due to difference in altitude and exposure. The areas at the extreme upper edge of the Lower Sonoran, 900 to 1,000 m in the St. George area and somewhat higher west of the Beaver Dam Mountains, in general suffered more, except where sheltered. But of specimens of *Larrea* growing side by side, with no apparent difference in conditions or size of plant, one would be frozen to the ground, while another might have only the tips of the branches nipped. Every degree of injury excepting actual death was present in a small area of uniform altitude and exposure. However, all plants of *Larrea* had evidently produced far less fruit this year than is usual for this species.

Contrary to Professor Cottam's conclusion that this occurrence "emphasizes the inadequacy of Merriam's theory of zonation in its failure to take into consideration temperature data of the dormant period," these later observations would indicate that, in this instance, at least, the ignoring of the dormant period was quite justified. And a week of sub-zero weather would seem to be quite a severe test. The facts suggest that the life zones are states of equilibrium reached by the vegetation as a result of the action of definite climates over a long period of time, and that they are not likely to be profoundly disturbed by brief intervals of "unusual weather."

F. R. FOSBERG

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EXPERIMENTAL STUDY OF THE SURVIVAL VALUE OF ACRIDIAN PROTECTIVE COLORATION

THE problem of protective coloration has recently received renewed attention in the scientific press: (Shull;[1,2] Carpenter;[3] McAtee;[4] O'Byrne;[5] Sumner;[6] Cockerell;[7] Carrick;[8] *et al.*).

The writer has for several years been carrying on a series of experiments attempting to determine the efficiency of native and domestic birds in discovering for food those grasshoppers whose color patterns appear to blend perfectly with the background of their environment.

The *predators, real enemies,* were mocking-birds, sparrows, cardinals, turkeys and bantams. Acridians noteworthy for their concealing resemblances, at least as far as the human observer is concerned, were the *prey.*

A garden plot 12×16 feet was marked off into squares 16×16 inches. These squares were arranged in checkerboard fashion to represent four different types of natural background: black, white and red soils; the fourth green, transplanted bermuda. The acridians were picketed on the various squares of the checkerboard plot or for some experiments anesthetized.

The native birds could be easily observed and checked from a screened porch and from the house windows. The domesticated birds permitted experimenters to follow their every movement.

The records of 33 experiments (June 9 to July 1, 1937) show that out of 459 acridians placed on non-harmonizing or non-protected backgrounds of the checkerboard plot and subjected to predator depredations, 405 or 88.24 per cent. were eaten by the birds, while 54 or 11.76 per cent. survived.

On the other hand, of the protectively colored acridians placed on harmonizing backgrounds 276 or 60.11 per cent. were missed by the birds, while only 183 or 39.85 per cent. of the acridians protected by concealing colors were eaten.

Since over 72 per cent. of the specimens used in these experiments were matched pairs it is evident that the more conspicuous were eaten, while the concealed or partly concealed were the individuals most likely to escape the keen eye of the predators. Further, it should be noted that in these matched pair tests a normally protected grasshopper became a non-protectively colored individual only because it was placed on a contrasting soil background rather than a harmonizing background. Therefore, when the bird-predator skipped a cryptically colored specimen of the same species, it was clearly a test of bird visual-perception.

The evidence shows that birds intent on securing acridians as insect-food often failed to see and repeatedly skipped or passed over protectively colored

[1] A. F. Shull, SCIENCE, 81: 443–452, 1935.
[2] A. F. Shull, SCIENCE, 85: 496–498, 1937.
[3] G. D. H. Carpenter, SCIENCE, 85: 356–359, 1937.
[4] W. L. McAtee, *Quart. Rev. Biol.*, 12: 47–64, 1937.
[5] Harold O'Byrne, *Ent. News.*, 44: 57–61, 1933.
[6] F. B. Sumner, *Proc. Nat. Acad. Sci.*, 21: 345–353, 1935.
[7] T. D. A. Cockerell, SCIENCE, 84: 203–206, 1936.
[8] Robert Carrick, *Trans. Royal Ent. Soc.*, 85: 131–138, 1936.

acridians, while the non-protected were much more consistently eaten.

All experiments point to but one general conclusion—concealing coloration protects acridians against bird predators.

The details of these experiments will be published elsewhere.

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COLUMNAR STRUCTURE IN EXTRUSIVE BASALTS

IN two recent texts on geology the impression is given that columnar structure in basalt is a characteristic of intrusive flows. In one text the lower canyon of Yellowstone River, near Tower Fall, is pictured on a plate entitled "Intrusions," with the caption: "Sills lie parallel to surrounding structures." Since the lower basalt at that point rests upon the "Tower Fall Conglomerate," a distinctive stream-gravel, there is no doubt that the bed represents a surface flow. At Overhanging Cliff a child of 14 can recognize the sand and gravel beneath the basalt and understand the porous and ashy contact of the lava on the stream bed. A more diagrammatic section of a lava flow could not be invented.

North of Tower Fall Ranger Station one can look across the river and see where the basaltic lava flowed northward onto the little valleys at the foot of the Precambrian Buffalo Plateau. The river has cut across these valleys and the intermediate ridges, showing in section the V-shaped valleys, all filled to the same level with columnar basalt. Certainly this was a surface flow. It appears to be a part of the flow at the canyon.[1]

Another text pictures Giant's Causeway as an example of intrusive basalt. Now if you stand on the Causeway and look east, you see a high cliff with two horizontal bands of red material lying between layers of columns. The red layers are ferruginous soils developed on the basalts between eruptions. What we really have at the Causeway is a series of successive surface flows of basalt, all of them hardening with columnar structure. To complete the story, near Portrush I collected charred pine wood—a log of it—and a perfect charred cone of the Strobus type between two layers of basalt. In the face of these statements the author of the book writes me that "the basalts of Giant's Causeway look like intrusives." These strata are well described and explained in a "Guide to Belfast . . . prepared for the British Association" (1892), and in other publications. Professor Charlesworth, of Queen's University, Belfast, in a letter recently received, restates the extrusive origin of the Giant's Causeway basalts. (*Cf.* Proc. London Geologists' Assoc., 1935.)

Columnar basalts, to be sure, often are intrusive. But care is needed in showing examples of such.

HENRY S. CONARD

GRINNELL COLLEGE

SOCIETIES AND MEETINGS

THE TENNESSEE ACADEMY OF SCIENCE

THE Tennessee Academy of Science, like the American Association for the Advancement of Science, was initiated by geologists. It was projected by Dr. George H. Ashley, now state geologist of Pennsylvania, promoted at Knoxville by Dr. C. H. Gordon, then professor of geology, University of Tennessee, at Nashville by Dr. L. C. Glenn, professor of geology, Vanderbilt University, and its first secretary was Wilbur A. Nelson, then assistant in the Tennessee Geological Survey, now professor of geology, University of Virginia. Botanists have taken the lead in recent years and were first to organize a section. At the meeting on November 26 and 27, 1937, at George Peabody College, sections in geology and physics were organized, and the three sections had sessions on Friday afternoon, with Dr. Jesse M. Shaver, chairman for botany, Dr. L. C. Glenn, for geology, and Professor Slack, for physics. At the general sessions of the academy, President Louis J. Bircher, of Vanderbilt University, presided on Friday morning and Vice-President Peyton N. Rhodes, of Southwestern University, on Saturday morning.

The two organizations affiliated with the academy, Tennessee Ornithological Society and the Barnard Astronomical Society, were represented on the program, Albert F. Ganier of the former discussing the subject, "Mid-winter Birds of the Nashville Area," and Mrs. Roberta Lyne, president of the Barnard Club, superintending an exhibit of Barnard manuscripts and the showing of a "McMath-Hulbert Observatory" motion picture film. Five papers by representatives of the federal and state departments of conservation indicated the interest of these organizations in the work of the academy.

Dr. C. H. Gordon, in his address, as the first president in 1912, urged the establishment of a "State Conservation Commission whose functions shall be to provide for the conservation of the material and human interests of the State including the waterpowers, forests, minerals and other resources and conditions affect-

[1] *Cf.* U. S. Geol. Surv. Folio 30, 1899.

ing the material and social welfare of the people." Governor Browning this year has established a department of conservation which has proposed an extensive educational program of conservation and is now engaged in a scientific study of the available natural resources of the state. In view of these facts the academy appropriately passed a resolution to appoint a conservation committee to arrange for cooperation.

The attendance of members at the meeting and the number of papers on the program were the largest in the history of the academy. The address of President Bircher at the academy dinner on "The Aims and Future of the Academy" was most timely for the closing meeting of the twenty-fifth year of the academy. After the address the reshowing of the natural color cinematograph films illustrating the fauna and flora of Reelfoot Lake added much to the enjoyment of the occasion. The Tennessee Legislature last April made an appropriation to the academy for the Reelfoot Lake Biological Station of $5,000 for the biennium 1937–39. The films were made by Dr. C. L. Baker, director of the station.

A field trip sponsored by the Geology Section and led by Kendall E. Born, of the Tennessee Division of Geology, was made on Saturday afternoon into the Wells Creek Basin, in Stewart County, the largest of the American cryptovolcanic structures.

The officers elected for 1937–38 were: *President,* Jesse M. Shaver, George Peabody College; *Vice-President,* Aaron W. Dicus, Tennessee Polytechnic Institute; *Secretary-Treasurer,* John T. McGill, Vanderbilt University; *Chairman,* Botany Section, Dr. H. M. Jennison, University of Tennessee; *Chairman,* Geology Section (not yet elected); *Chairman, Physics Section,* Dr. Francis G. Slack, Vanderbilt University.

JOHN T. MCGILL

VANDERBILT UNIVERSITY

THE FLORIDA ACADEMY OF SCIENCES

THE second annual meeting of the Florida Academy of Sciences was held at the University of Miami, Coral Gables, Florida, on November 18, 19 and 20. November 18 was devoted to two all-day field trips. One of these was a marine zoological trip under the direction of Professors J. F. W. Pearson and E. M. Miller, of the University of Miami. About thirty-five members of the academy were carried by boat down Biscayne Bay and outside to Fowey Light below Soldier Key. The boat carried diving equipment, and each person was given the opportunity of going to the bottom in about eighteen feet of water and viewing the underwater life.

The other all-day field trip was botanical in nature and was under the direction of Professors W. S. Phillips and W. M. Buswell, of the University of Miami. The group went to Costello Hammock, one of the many hammocks typical of the region between Miami and Homestead. Mangrove swamps and salt marshes were visited, and the return trip was through the Miami pinelands to the Everglades. Some interesting transitions between these two localities were observed.

On the afternoon of November 19 six papers were presented in a general session, five papers in the Biological Sciences Section and five papers in the Physical Sciences Section.

On the evening of November 19 the annual banquet of the academy was held, with Professor Jennie Tilt, of the Florida State College for Women, vice-president of the academy, as toastmaster. President Bowman F. Ashe, of the University of Miami, delivered an address of welcome, and the retiring presidential address, "The Background of our Knowledge of Florida Plants," was delivered by Dr. H. Harold Hume, director of research of the University of Florida Agricultural Experiment Station.

The achievement medal for an outstanding paper delivered at the 1936 annual meeting of the academy was presented to Dr. H. Harold Hume for his paper, "Cohering Keels in Amaryllids and Related Plants."

On November 20 six papers were presented in the Biological Sciences Section, three papers in the Physical Sciences Section, and two papers in a general session.

At the business session officers for 1938 were elected as follows: *President,* Dr. R. I. Allen, Stetson University; *Vice-President,* Miss Charlotte B. Buckland, Landon High School, Jacksonville; *Secretary,* Dr. J. H. Kusner, University of Florida; *Treasurer,* Dr. J. F. W. Pearson, University of Miami; *Chairman of Biological Sciences Section,* Dr. L. Y. Dyrenforth, St. Luke's and Riverside Hospitals, Jacksonville; *Chairman of Physical Sciences Section,* Dr. B. P. Reinsch, Florida Southern College.

About 100 members and guests were present.

J. H. KUSNER,
Secretary

THE OKLAHOMA ACADEMY OF SCIENCE

THE twenty-sixth annual meeting of the Oklahoma Academy of Science was held at the University of Oklahoma, Norman, Okla., on December 3 and 4, 1937. Of the 410 members, approximately 250 attended the meeting. Ninety-five papers were presented in the various sections.

Dr. Dwight M. Moore, head of the Department of Botany of the University of Arkansas, gave the annual address on Friday evening, December 3, in the Engineering Auditorium. The title of his lecture was "Wild Flowers in Relation to their Environment."

Dr. B. D. Barclay gave the annual presidential address at the luncheon held on Saturday in the Oklahoma Union ballroom. He spoke on "Contributions of Morphology to Modern Plant Science."

The Research Award of $50, for 1937, financed by the American Association for the Advancement of Science, was made to Dr. Milton Hopkins, of the Botany Department of the University of Oklahoma.

The annual business meeting was held on Saturday, December 4. Miss Edith R. Force, Tulsa, Okla., was made a fellow in the society, and the following officers were elected for 1938:

President: C. M. Perry, University of Oklahoma.

Vice-Presidents:

Section A—F. A. Fenton, Oklahoma Agricultural and Mechanical College.

Section B—O. F. Evans, University of Oklahoma.

Section C—J. E. Webster, Oklahoma Agricultural and Mechanical College.

Section D—G. M. Rankin, Central State Teachers College.

Secretary-Treasurer: G. L. Cross, University of Oklahoma.

Assistant Secretary-Treasurer: H. I. Featherly, Oklahoma Agricultural and Mechanical College.

G. L. CROSS,
Secretary-Treasurer

SPECIAL ARTICLES

SULPHANILAMIDE AND VIRUS DISEASES

SINCE the report of Domagk[1] in 1935 concerning the chemotherapeutic action of Prontosil in streptococcal infections, it has been found that a fraction of the Prontosil molecule, para-aminobenzene sulphonamide (sulphanilamide), is also effective in streptococcal infections and in a few other bacterial infections as well (meningitis, gonorrhea, etc.).

Naturally one of the early questions which arose was the possibility of using these chemotherapeutic agents in virus diseases. In September, 1937, Rosenthal, Wooley and Bauer[2] reported that Prontosil possessed therapeutic activity against the virus of choriomeningitis in mice but that sulphanilamide and Prontosil Soluble were inactive.

We have recently tested experimentally three additional virus diseases with sulphanilamide (Prontylin) with results similar to those described by the above authors. Since this subject is a very active one in the field of medical research at the present moment and since the mode of action of these drugs is of such interest, we wished to call particular attention to the apparent negative action of sulphanilamide on the virus diseases we have tested.

Employing sufficient numbers of animals for experimental infection and for controls we tested the activity of sulphanilamide against the viruses of poliomyelitis, rabbit fibroma and rabbit myxomatosis. In the poliomyelitis experiments a group of monkeys was inoculated intracerebrally with mixed poliomyelitis virus. Forty-eight hours later several of these animals were given subcutaneous injections of sulphanilamide, while others received no treatment with the drug and were kept as controls. The animals treated were given one-half gram of the drug, suspended in physiological salt solution, per kilogram of body weight. The treatments were continued for five successive days. The animals received a total of from six to twelve grams of the drug, depending upon their weights. All the monkeys died, including the controls, in from ten to fourteen days with typical symptoms of poliomyelitis except one monkey, which survived for twenty-seven days. This animal had received the drug daily for five days, beginning forty-eight hours following injection, and a total of 9.1 grams of sulphanilamide were administered. Kelson[3] has also reported negative results in experimental poliomyelitis when animals were infected by the intranasal route.

Rabbits experimentally infected with fibroma and myxoma viruses, respectively, were also given subcutaneous treatments with the drug. The dosage used was the same as in the experiments with poliomyelitis virus. An equal number of infected, but untreated, animals were kept for controls. In the case of myxoma virus all the animals, both treated and untreated, died with myxomatosis on the tenth to twelfth day following injection with the virus. Treatments with sulphanilamide were begun forty-eight hours following injection with virus and were continued for three successive days. Experiments with fibroma virus were carried out similarly, and all animals, treated and untreated, developed fibroma, except for two controls which died of an intercurrent infection.

These negative results with sulphanilamide in treating experimental virus infections raise certain questions regarding the mode of action of this drug, particularly in view of a few bacterial diseases in which it is apparently highly efficacious. One of the essential differences between virus and bacterial infections is that the former are invariably of an *intracellular* nature while the latter are chiefly *intercellular,* though in some bacterial diseases cellular invasion is also characteristic. It is suggested that sulphanilamide is un-

[1] G. Domagk, *Deutsch. Med. Wchnschr.,* 61: 256, 1935.

[2] Sanford M. Rosenthal, Jerald G. Wooley and Hugo Bauer, *Pub. Health Rep.,* 52: 1211–1217, 1937.

[3] Saul R. Kelson, *Proc. Exp. Biol. and Med.,* 36: 718–720, 1937.

able to exert its action (?—bacteriostatic, virustatic or what-not) against the infecting agent when it has invaded the tissue cells as in the case of virus infections. The efficacy of sulphanilamide in specific bacterial diseases may depend partly on its successful attack against extracellular organisms, while the host cells themselves are contributing to the defense against the invading microbes. On the other hand, we may assume from present evidence that viruses find conditions within the tissue cells favorable, rather than unfavorable, for survival and multiplication.

EARL B. MCKINLEY
ELLEN GRAY ACREE
JEAN SINCLAIR MECK
SCHOOL OF MEDICINE, THE GEORGE WASHINGTON UNIVERSITY

THE SKIN INFECTIVITY OF POLIOMYELITIS VIRUS

ALTHOUGH controversy exists as to the mode of spread of poliomyelitis, a generally accepted view is that the virus gains access to the central nervous system via the olfactory nerves. This theory is supported by the fact that it has been found easier to infect monkeys intranasally than by other routes, such as the gastrointestinal, intravenous, sub- or intra-cutaneous route. A fact which does not appear to be well known, however, is that this generalization as to infectivity via different routes does not apply equally to all strains of the virus. For with some strains of poliomyelitis virus, monkeys are readily infected on intracutaneous inoculation of doses which are not particularly large. This is illustrated by our results shown in Table 1 to which we will again refer.

The literature also furnishes evidence of this fact. In France during the course of some immunization experiments Erber and Pettit[1] inoculated subcutaneously serum-virus mixtures (which represented a pool of four different strains of virus) into 13 monkeys, and 12 of these animals succumbed to poliomyelitis as a result of this inoculation. Later two of these four strains were found to have this property of infectivity by the subcutaneous route. Levaditi *et al.*[2] have noted that as many as 10 out of 17 animals were infected subcutaneously from poliomyelitis vaccines. Further preliminary evidence bearing on this question may be found in the description of a strain (our Wfd. strain), which we reported in 1936, which in its early passages was peculiarly infective by the cutaneous route.[3] It had been isolated in the 1934 epidemic in southern California. Later two other new strains showing cutaneous infectivity were isolated in California, one by Howitt[4] and one by Kessel and his coworkers.[5]

It next seemed important to determine how frequently this property of intracutaneous infectivity could be found. Was it a rare or a common property of strains isolated in Eastern sections of this continent as well as in the West; was it a property of established strains as well as fresh strains? To this end we have examined a number of strains of virus from various sources during the last two years, and the results, which form the substance of this note, appear in Table 1.

TABLE 1
CUTANEOUS INFECTIVITY OF ELEVEN STRAINS OF POLIOMYELITIS VIRUS*

	Name of strain	Source		No. of monkey passages	Result
Established strains	Park	N. Y. C., ?	1916	Many	1/7†
	Aycock	Vermont,	1921	"	0/6
	Flexner	N. Y. C.,	1931	11–18	1/7
	We.	New Haven,	1931	9–15	0/7
	McC.	Los Angeles,	1934	3–10	0/7
	Wfd. (a)	" "	1934	3– 7	6/10
	" (b)	" "	1934	8–16	4/11
	Hub.	Boston, Mass.,	1936	4– 5	0/4
	Gr. (b)	Memphis, Tenn.,	1936	4– 5	0/2
Fresh strains	Gr. (a)	Memphis, Tenn.,	1936	1– 2	1/3
	Fx.	Toronto,	1937	(Human)	1/1
	Ah.	"	1937	"	1/1
	McL. (a)	"	1937	"	2/2
	" (b)	"	1937	1	0/1

* The same dose was used with all 11 strains, *viz.*, 2 c of a 10 per cent. suspension of spinal cord given intracutaneously (and rarely subcutaneously) in 8 or 10 piqures in the shaved skin of the flanks or abdomen.
† 1/7 indicates that seven monkeys were cutaneously inoculated and that, of these, one was infected with clear-cut experimental poliomyelitis.

Eleven different strains were investigated. They have been arbitrarily divided into two major groups—established strains and fresh strains. Established strains are those which had been passed in series (by intracerebral inoculation) through more than three monkeys.[6] Two of these established strains (Park and Aycock) were quite old and had been through many monkey passages (perhaps 100 or more). Four fresh strains were tested, the recent (1937) epidemic in Toronto having furnished us with three of them.[7]

Most of our established strains, are (or were) of high intracerebral virulence and most of them infect by the intranasal route, but from Table 1 we note that cutaneous infectivity is seldom a prominent feature except in one strain, the Wfd. strain, which, so far, has not been infective intranasally. At first about 60 per

1 B. Erber and A. Pettit, *Comp. rend. Soc. de biol.*, Paris, 117: 1175–1178, 1934.
2 C. Levaditi, C. Kling and P. Haber, *Bull. Acad. méd.*, Paris, 3e Série, 115: 431–440, 1936.
3 J. D. Trask and J. R. Paul, *Jour. Bacteriol.*, 31: 527–530, 1936.
4 B. F. Howitt, SCIENCE, 85: 268–270, 1937.
5 Personal communication from F. D. Stimpert.
6 A description of six of these established strains has been given in a recent article by the authors, *viz.*, J. D. Trask, J. R. Paul, A. R. Beebe and W. J. German, *Jour. Exp. Med.*, 65: 687–704, 1937.
7 For these three strains we are particularly indebted to Dr. L. N. Silverthorne, of the Hospital for Sick Children, Toronto, Canada.

cent. of the animals inoculated intracutaneously with this strain were infected. Later (after the seventh passage) this property seemed to decrease and about 25 per cent. were infected. But, among the seven other established strains, cutaneous infectivity was not at all pronounced; in fact, it was quite uncommon. In 40 tests there are only two instances (5 per cent.) in which monkeys were infected by these seven other strains from our so-called established group.

Somewhat in contrast to this is the action of the fresh strains. The number of animals tested is small but large enough to indicate a substantial degree of intracutaneous infectivity of not only human material (*i.e.*, prior to its first passage) but also of the virus during its first two passages. In fact, all the few fresh strains which we so far have tested have shown this property in at least a third of the inoculated animals, and the total percentage of animals cutaneously infected in this particular series is about 60 per cent. This appears all the more remarkable when one recalls the difficulties of getting human poliomyelitis virus established in the monkey by the intracerebral route in its earliest passages, and when one also considers that in the present experiments almost the same dose has been used for these intracutaneous as for the intracerebral inoculations. It remains to be seen whether this apparent difference between the behavior of fresh and established strains is a coincidence or not.[8]

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THE EFFECT OF COPPER IN THE PRODUCTION OF NUTRITIONAL ANEMIA IN RATS

DISCREPANCIES in the bioassay results from different laboratories relative to the availability of iron in foodstuffs have been variously explained by Elvehjem and coworkers[1,2,3] and by Smith and Otis.[4] Elvehjem believed that failure to effect complete depletion of iron storage in the experimental animals was the reason for these discrepancies, while Smith and Otis postulated a sex difference in the ability of anemic rats to utilize iron, and attributed differences in results from various laboratories to ignorance of this fact. Mitchell and Hamilton[5] concluded from their paired-feeding studies that the sex difference noted by Smith and Otis was partially, or entirely, the result of a greater intake of the anemogenic basal diet by the male rats. Smith and Otis[6,7] in recent papers have suggested and attempted to prove that copper administration during the depletion period is necessary to assure complete exhaustion of the iron reserves. They believe that failure to completely eliminate these potentially available iron reserves in the depletion period has often resulted in invalid conclusions being drawn from subsequent curative data. They contend that part, at least, of the hemoglobin response was due to the copper of the food under assay rather than to its available iron content.

In this laboratory we have had occasion to deplete large numbers of rats for hemoglobin regeneration studies. Two small groups of these were depleted in the usual way, except that whole milk powder (Klim) was substituted for whole fresh milk, while other groups received in addition to this same basal diet a daily supplement of 0.05 mg copper as copper sulfate. The results are shown in Table I. Whereas Smith and Otis found that by supplementing the basal diet with copper, beginning at the fourth or at the sixth week of depletion, an immediate and sustained increase in hemoglobin occurred, we have found that the trend of hemoglobin values during the depletion period is not significantly affected by the presence of copper in the basal depletion ration.

TABLE I

SHOWING COMPARATIVE HEMOGLOBIN DECREASE IN RATS FED WHOLE MILK POWDER WITH AND WITHOUT COPPER

Supplement to basal diet	No. of rats used	Sex	Initial hemoglobin (gms/100 cc)	Decrease in hemoglobin (gms/100 cc)		
				In 3 weeks	In 5 weeks	In 7 weeks
None	10	M	12.26	5.59 ± .55	8.44 ± .20	9.08 ± .20
None	10	F	12.18	3.85 ± .58	8.31 ± .31	9.03 ± .36
0.05 mg Cu as $CuSO_4$.	10	M	11.77	4.84 ± .33	8.01 ± .27	8.48 ± .30
0.05 mg Cu as $CuSO_4$.	10	F	11.77	5.18 ± .40	8.25 ± .27	8.78 ± .21

To determine the effect of subsequent iron feeding upon anemic rats depleted with and without copper, five animals from each of the previous groups were fed a daily curative supplement, consisting of 0.1 mg Fe as $FeCl_3$, 0.05 mg Cu as $CuSO_4$ and 0.04 mg Mn as $MnCl_2$, for a period of six weeks.

According to Smith and Otis,[8] at this level of iron

[8] Aided by grants from the President's Birthday Ball Commission for Infantile Paralysis Research.

[1] C. A. Elvehjem and A. R. Kemmerer, *Jour. Biol. Chem.*, 93: 189–195, 1931.

[2] C. A. Elvehjem, E. B. Hart and W. C. Sherman, *Jour. Biol. Chem.*, 103: 61–70, 1933.

[3] W. C. Sherman, C. A. Elvehjem and E. B. Hart, *Jour. Biol. Chem.*, 107: 383–394, 1934.

[4] M. C. Smith and L. Otis, SCIENCE, 85: 125–126, 1937.

[5] H. H. Mitchell and T. S. Hamilton, SCIENCE, 85: 364–366, 1937.

[6] M. C. Smith and L. Otis, *Jour. Nutrition*, 13: 573–582, 1937.

[7] M. C. Smith and L. Otis, *Jour. Nutrition*, 14: 365–371, 1937.

[8] *Op. cit.*

feeding, standard anemic male rats gained 5.5 ± 0.14 grams hemoglobin in six weeks, while females gained 6.5 ± 0.15 grams of hemoglobin. However, when the rats had been made anemic in the presence of copper, presumably from the fourth or sixth week on, the hemoglobin gain for males and females over six weeks was only 3.00 ± 0.28 and 4.50 ± 0.23 grams, respectively. Our results (Table II) indicate that no significant lessening of hemoglobin response occurred when copper had been fed throughout the entire depletion period as compared with hemoglobin response when regular depletion had been carried out. However, we noted a continuance of sex variation in response to iron feeding regardless of depletion technique. This does not corroborate the findings of Smith and Otis that sex variation diminished when copper was furnished during depletion and who believed that it would disappear entirely if a longer period of copper feeding were carried out.

TABLE II
SHOWING HEMOGLOBIN REGENERATION DURING CURATIVE PERIOD OF RATS MADE ANEMIC WITH AND WITHOUT COPPER

Amount of iron fed daily (mg)	Supplement to basal diet during depletion	No. of rats	Sex	Initial hemoglobin (gms/100 cc)	Gain in hemoglobin in 6 wks. curative period (gms/100 cc)
0.10	None	5	M	3.28	4.72 ± .22
0.10	None	5	F	3.15	5.76 ± .19
0.10	Copper	5	M	3.30	4.60 ± .24
0.10	Copper	5	F	3.00	5.83 ± .20

It must be concluded from results obtained in this laboratory that supplementing the basal diet with copper in anemia production does not significantly affect the time nor severity of iron depletion, nor does it affect the hemoglobin response to subsequent iron feeding.

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THE ABSORPTION OF SELENIUM BY CITRUS AND BY GRAPES

PLANTS differ greatly in their ability to accumulate selenium from the soil.[1]

This situation is of importance in connection with any public health hazards which may follow from the use of insecticidal sprays containing selenium. Hence the results of analyses of citrus fruit and grapes from plots which have been treated for several years with the commercial product Selocide and from nearby untreated plots may be of interest. This material corresponds in composition to the empirical formula $(KNH_4S)_5Se$ and is sold as a 30 per cent. aqueous solution.[2]

It was used for the control of the Pacific mite, *Tetranychus pacificus,* on grapes and of the citrus red spider, *Paratetranychus citri,* on citrus. The usual dilution was 1–800 on citrus and 1–600 on grapes. Samples of fruit were picked at random. All citrus fruit was washed in dilute nitric acid in order to remove adhering selenium from the exterior. Soil samples were taken at the edge of the trees or vines where the run-off of spray was heaviest. Only composite results for 0–36 inches depth are given in Table I:

TABLE I
A. CITRUS

Plot	No. applications	Se in soil 0–36″	Se in fruit	
			skin	pulp
		ppm		ppm
A (l)*	6 (1932–36)	0.91	0.09	0.07
AA (v.o.)†	None	0.28	0.13	0.12
B (v.o.)	6 (1933–36)	0.46	0.47	0.07
BB (v.o.)	none	0.29	0.07	0.03
C (l)	5 (1934–36)	0.80	0.31	0.06
CC (l)	none	0.27	0.12	0.09
D (v.o.)	3 (1935–36)	0.61	0.22	0.12
DD (v.o.)	none	0.30	0.10	0.02
E (v.o.)	3 (1933–36)	0.27	0.17	0.07
EE (v.o.)	none	0.35	0.09	0.04
F (l)	5 (1933–35)	0.93	0.18	0.02
FF (l)	none	0.60	0.10	0.02
G (l)	1 (1936)	0.21	0.22	0.03
GG (l)	none	0.12	0.08	0.01
H (v.o.)	2 (1934)	0.53	0.09	0.03
HH (v.o.)	none	0.31	0.06	0.02

* (l) = lemons.
† (v.o.) = Valencia oranges.

B. THOMPSON SEEDLESS GRAPES

Field	No. applications	Se in soil 0–36″	Se in grapes	
			unwashed	washed
4	5 (1933–37)	0.49	1.80	0.64
4	2 (1933–34)	...	0.14	...
13–1	2 (1935–36)	...	0.23	...
4	none	0.25	0.11	...

On the basis of these results the following conclusions seem to be justified:

(1) Se occurs in all untreated soils tested at about 0.25 ppm.

(2) Se in soils of plots sprayed up to six times was always less than 1 ppm.

(3) The average Se content of the sprayed citrus fruits was: skin 0.21 ppm., pulp 0.06 ppm.

(4) The average Se content of the unsprayed citrus fruit was: skin 0.10 ppm., pulp 0.05 ppm.

(5) Grapes from vines sprayed during the current year contained over 0.6 ppm. Se, but the amount was much less when selenium was used in earlier years only.

(6) Neither citrus trees nor grape vines concentrate

[1] O. A. Beath *et al., Jour. Am. Pharm. Assn.,* 26: 394–405, 1937; H. G. Byers, *U. S. Dept. Agr. Tech. Bul.* No. 482, 48 pp., 1935.

[2] C. B. Gnadinger, *Jour. Ind. Eng. Chem.,* 25: 633–1933.

large amounts of selenium in their fruit as a result of spraying with selenium dissolved in potassium ammonium sulfide solution for the control of red spider.

A complete account of this and other work on selenium carried out in the California Agricultural Experiment Station is in process of compilation.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

GROWTH SUBSTANCE DETERMINATIONS

THE Went *Avena*-coleoptile test and the *Cephalaria* test of Söding are the most sensitive ones that have been devised for quantitative hormone studies. These tests, however, are available only to a few laboratories which have facilities for the accurate regulation of temperature, humidity, etc.

The authors have developed a method of hormone determination which requires only the facilities available in every botanical laboratory. The manipulation is simple, no special apparatus is required, and the method is applicable over a wide range of growth substance concentrations. It may be used for detection of hormones at the low concentrations to which the *Avena* coleoptile responds, but so far as the method has been tested, does not appear to be available for the detection of minute differences within the low range of concentrations, as do the *Avena* and *Cephalaria* tests.

The new method depends on the fact that when etiolated seedlings of *Lupinus albus,* decapitated below the cotyledons, are exposed to light, growth ceases almost completely. However, when a growth substance is applied to the cut surface of the hypocotyl, elongation of the hypocotyl takes place in the presence of light, and this elongation is proportional to the concentration of the growth substance applied.

Some twelve or fourteen *Lupinus albus* seeds of approximately uniform size are planted in six-inch pots in sand. They are germinated in a dark room for six to seven days, or until the hypocotyls are seven to eight centimeters high. In the morning the pots are brought into the light, and the seedlings are selected for uniformity. The cotyledons are cut off with a razor blade, at the apex of the V-shaped notch which they make with the hypocotyl. A mark is made one centimeter below the cut, with India ink, and the growth substance is applied in an agar block, or in lanolin paste to the cut surface of the hypocotyl. The pots are placed under bell jars in order to insure high humidity and are exposed to full daylight. On the morning of the fourth day, the increase in length of the original centimeter segment is measured. Ten to fifteen test plants are used for each determination. With low concentrations of growth substances, control plants treated with lanolin or agar only are run in the same pot with the test plants. Indole-3-n-acetic acid in appropriate dilutions is used as a standard.

A straight-line relationship is obtained when high concentrations of heteroauxin ($100\,\gamma - 0.01\,\gamma$) are plotted logarithmically against increase in growth. However, in the lower range of heteroauxin concentration detected by the *Avena* test[1] ($0.01\,\gamma - 0.001\,\gamma$) the curve rounds off.

The wide range of concentrations to which the hypocotyls respond should make this test especially applicable to the study of the growth-promoting activities of various substances that are not inactivated by light. Moreover, a test object whose physiological make-up is somewhat different from that of *Avena*[2] should prove of value in attempting to understand the mechanism of growth reactions.

The authors have had the benefit of Professor F. G. Gustafson's interest and advice in the studies, which will be described later in greater detail.

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A BODY PLETHYSMOGRAPH FOR MEASURING RESPIRATORY VOLUMES WITH HIGH RESPIRATORY RATES

WHEN animals which are deficient in sweat glands, *i.e.,* dog, cat, rabbit, etc., are exposed to heat they develop a peculiar type of respiration called "heat polypnea" or "panting." The ventilation and respiratory rate increase, while the tidal volume decreases. With dogs respiratory rates may reach over 300 per minute. In measuring respiratory volumes of panting animals it is customary to use a tracheal canula or mask connected through valves to a recording system such as a respirometer or gas meter. Objections to this method include the following: (1) either anesthetics must be used or the respiratory pattern becomes subject to artificial alterations due to pressure stimuli, pain, etc.; (2) the dead space of the apparatus does not match that of the normal animal; (3) canulae impede air movement; (4) the purpose of panting is to blow air over the moist surface of mouth, tongue and pharynx for purposes of evaporation and this cooling mechanism is lost to the canulated animal; (5) moving mechanical systems have the disadvantages of having appreciable inertia and of giving false records when the respiratory period approaches or becomes less than the natural period of the moving system. In order to

[1] George S. Avery, Jr., Paul R. Burkholder and Harriet B. Creighton, *Am. Jour. Bot.*, 24: 226–232, 1937.

[2] Sam Granick and H. W. Dunham, Papers, Mich. Acad., 22: 69–78, 1936.

eliminate the above sources of error, the recording plethysmograph shown schematically in Fig. 1 was built.

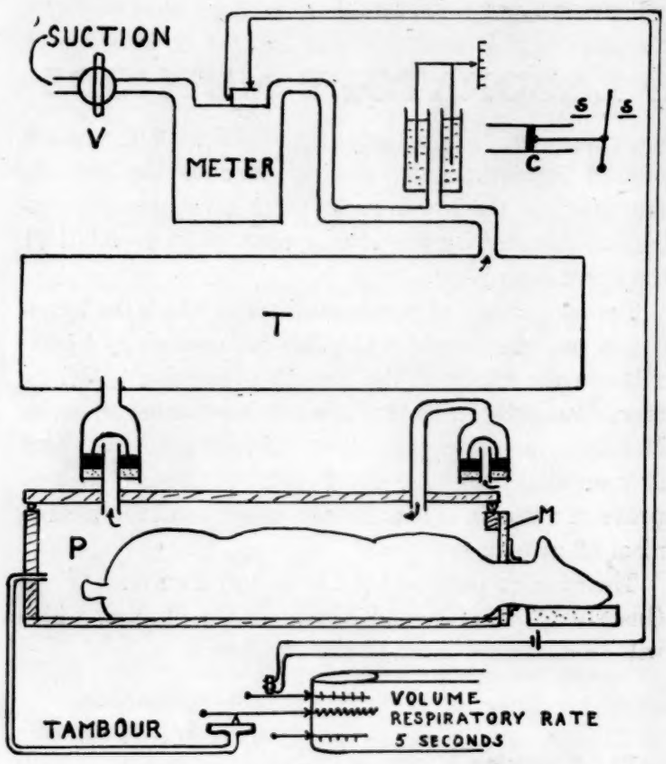

FIG. 1

The recumbent dog lies within a box (P) closed except for valves and tambour outlets, with head protruding through a seal. The seal consists of a spongy rubber mat with a hole just large enough to permit the head of the dog to go through. A circular hole is cut in a piece of dental rubber dam and this is placed around the dog's neck to fit tightly. Adhesive tape seals the rubber dam to the dog's neck and the rubber mat, which is then clamped by a brass frame tightly to the edge of a large hole in the plethysmograph. When carefully placed a dog experiences no discomfort and a trained animal will lie quietly for six hours in the apparatus. The lid of the apparatus is clamped on tightly, soft rubber tubing acting as a washer.

Each of the two box valves consists of a half ping-pong ball seated on mercury. The inlet valve admits room air to the plethysmograph during expiration. During inspiration this air is forced through the outlet valve into a large 150 liter sealed tank (T). From the tank (T) an outlet tube leads to a sensitive spirometer and a dry gas meter. The cylinder of the spirometer is of aluminum, displaces 20 ml per cm and is carefully counterweighted. The meter has electrical contacts which record every one fifth of a revolution representing about 750 ml between contacts. A manually operated valve (V) controls the measured amount of air drawn from (T).

In operation the dog draws air into (P) by expiration and forces the air into (T) during inspiration. Pressure builds up in (T) causing the cylinder of the spirometer to rise. Suction then withdraws air from (T) until the spirometer has returned to its original position. During rapid respirations of 300 per minute, to which the small spirometer can not respond, the large air volume in (T) has added to it by rapid pulsations relatively small quantities of air which build up the pressure. The large air volume acts as a pneumatic cushion to the air pulsations. It is important to have the tank (T) at a slight positive pressure, otherwise air would be drawn through the entire system without breathing. A kymograph record contains a 5 seconds time line, a tambour tracing of rate and a record of the volume of air passing through the plethysmograph, as indicated by the meter contacts.

The apparatus was tested by using a cylinder and piston arrangement (C). The free open end of this cylinder was placed through a hole in the mat (M). Closed containers approximately equal in volume to the dogs were placed in (P). The piston was then moved back and forth between stops (S) at rates simulating respiration. The volume of air drawn into and expelled from (P) could be computed from the stroke and area of the piston.

With this testing procedure the following methods of recording the ventilation rate were tested: (a) a large tambour over a large hole in (P); (b) the small spirometer directly connected to (P); (c) the inlet valve connected to the spirometer and the outlet valve discharging to the room air; (d) the inlet valve opening to the room and the outlet valve discharging air through a wet or dry gas meter; (e) the differential method as described above. As a result of these tests it was found that for respiratory rates exceeding 100 per minute method (e) was the only one giving satisfactory checks. The other methods (a)–(d) depended on some mechanical recorder stopping and starting with each respiration. For rapid respirations the starting inertia was too great to be overcome by the low driving pressures of the plethysmograph.

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